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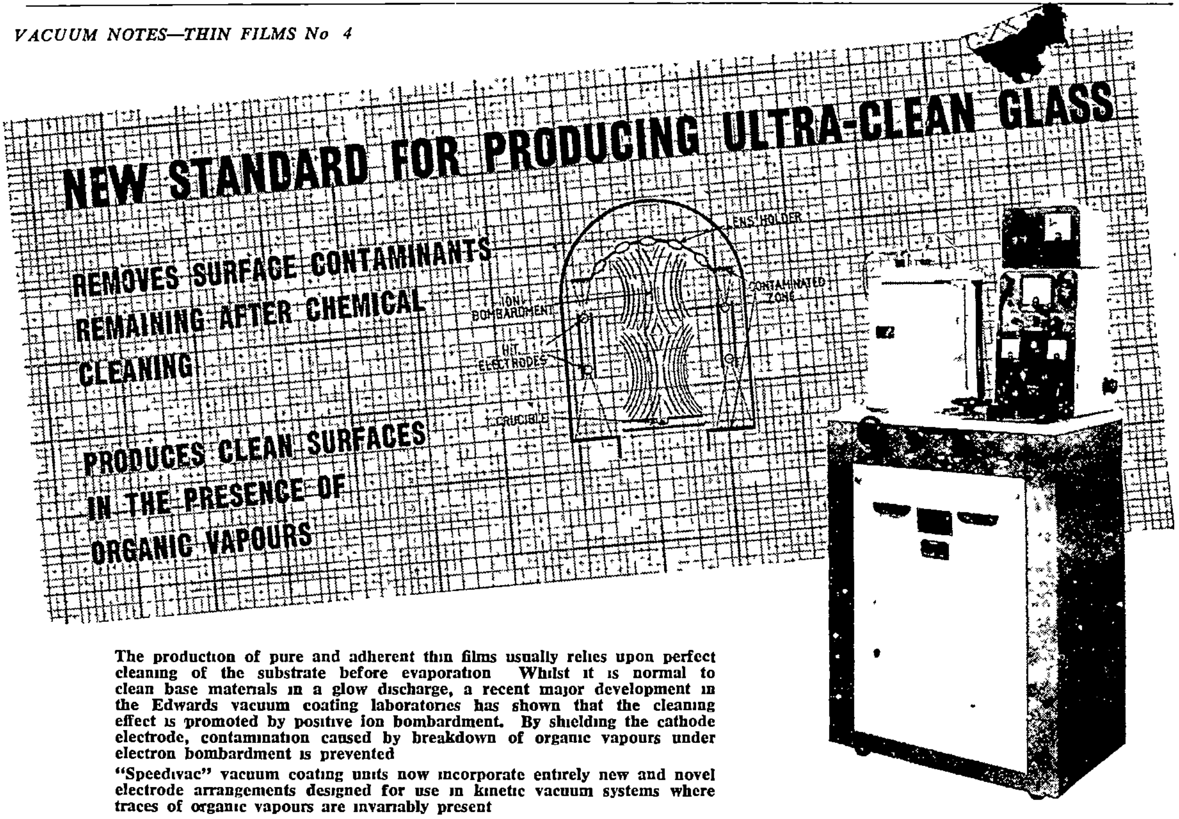
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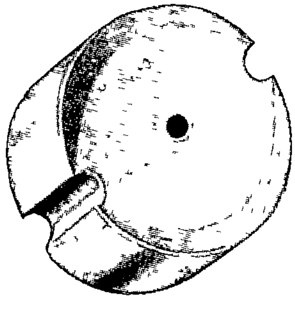

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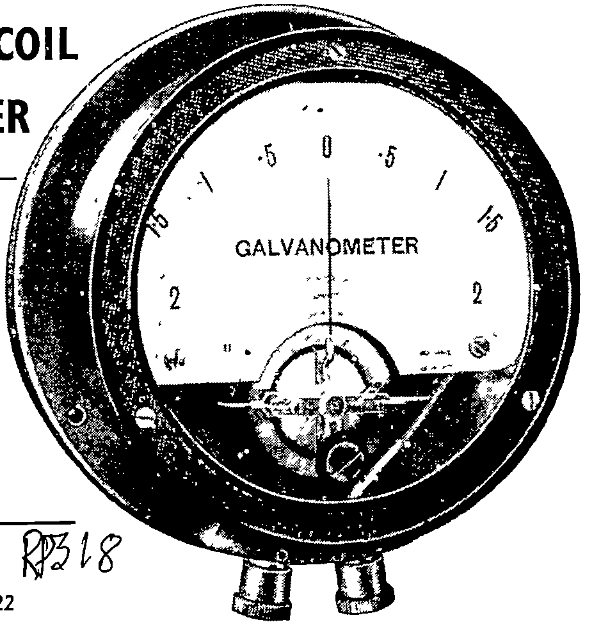

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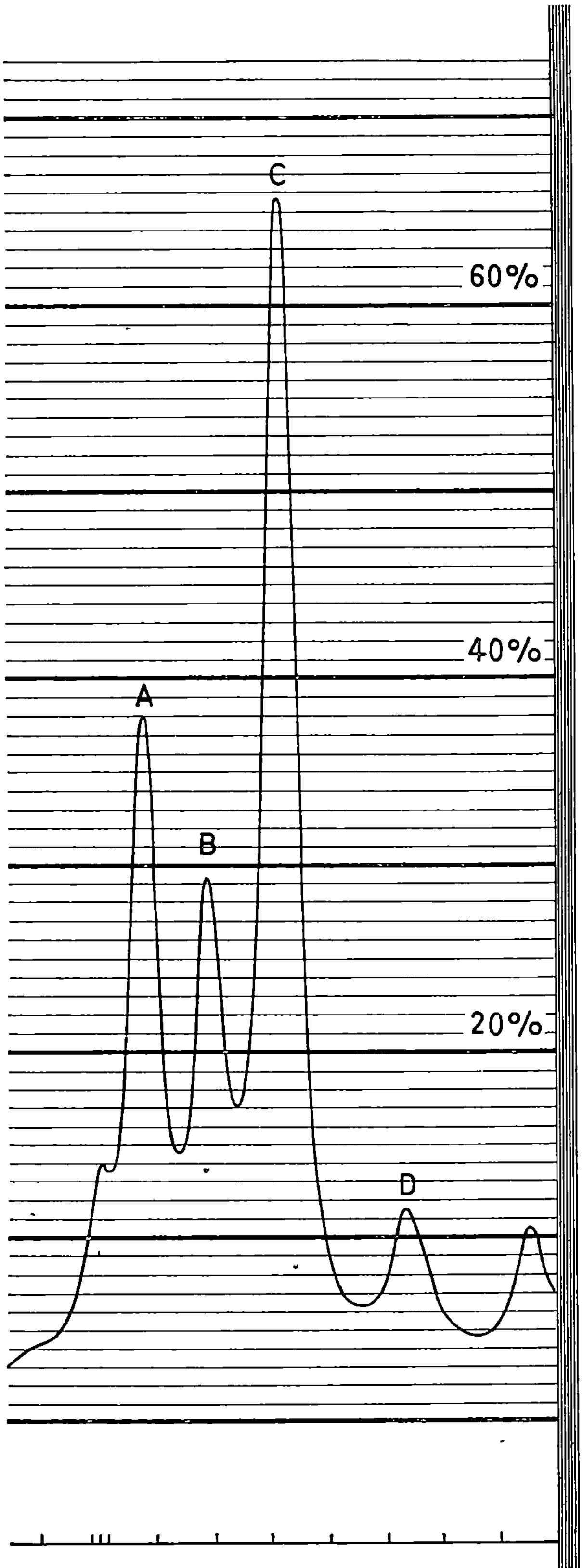

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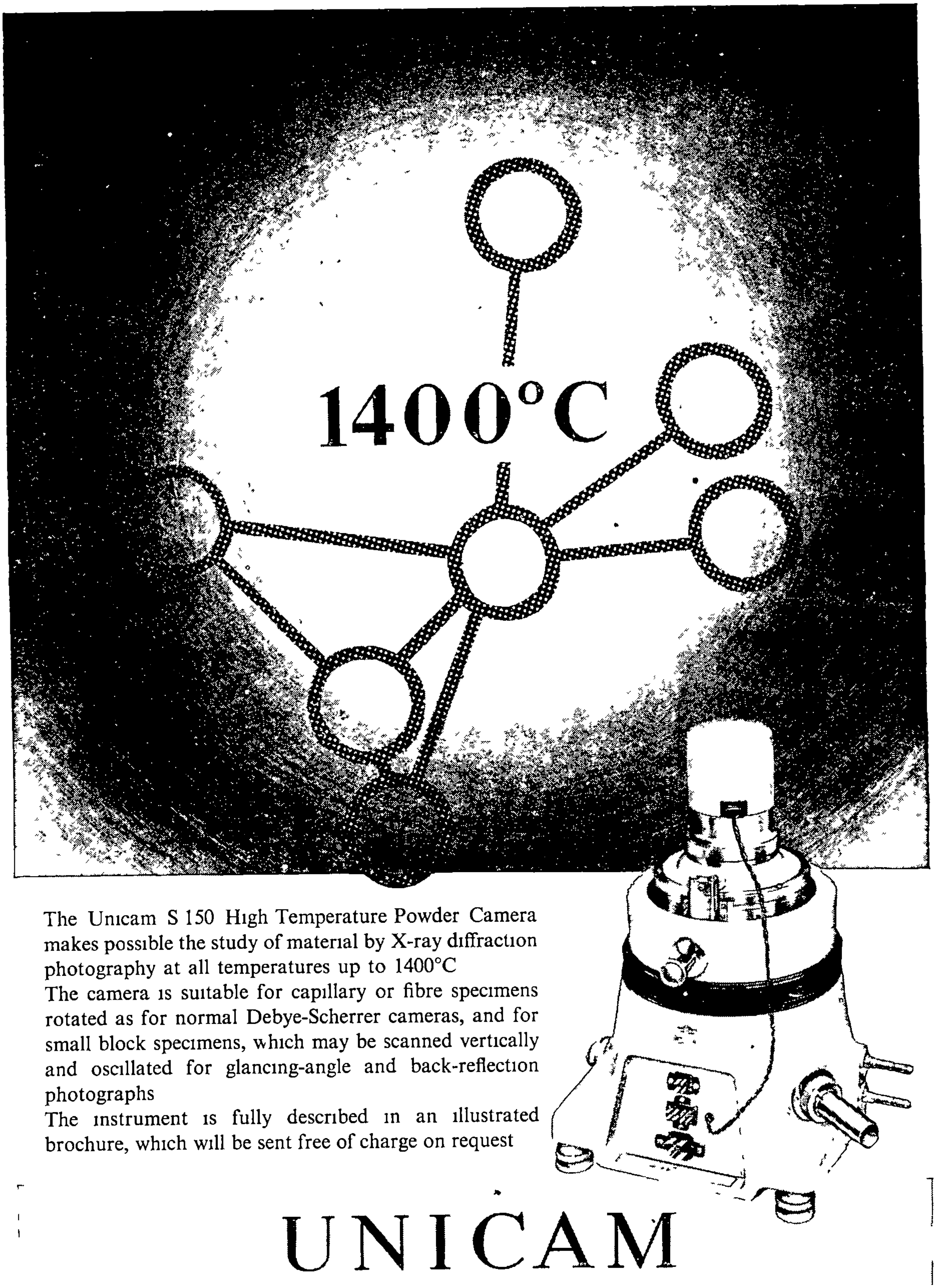

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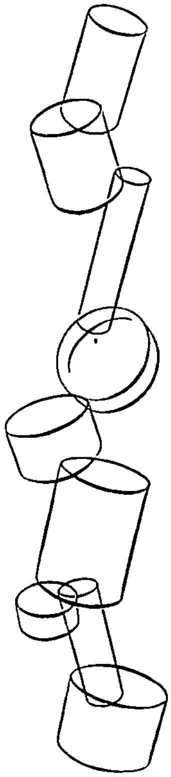

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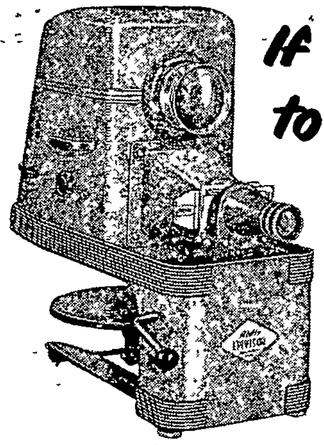

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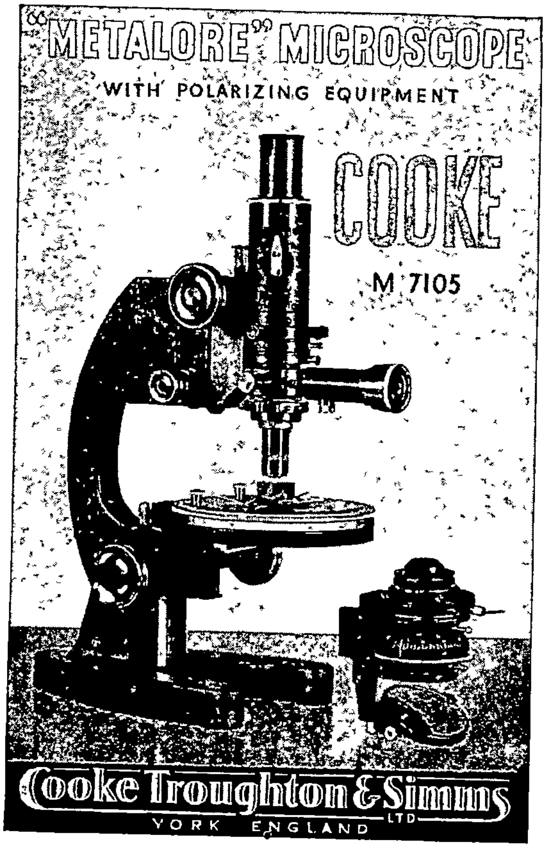

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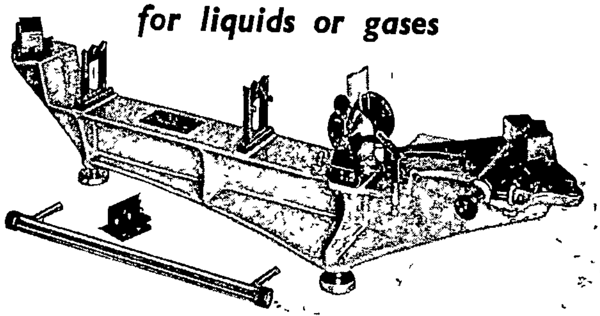

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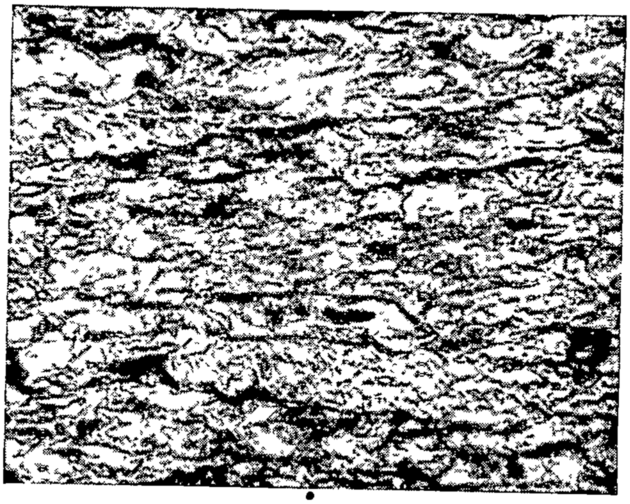

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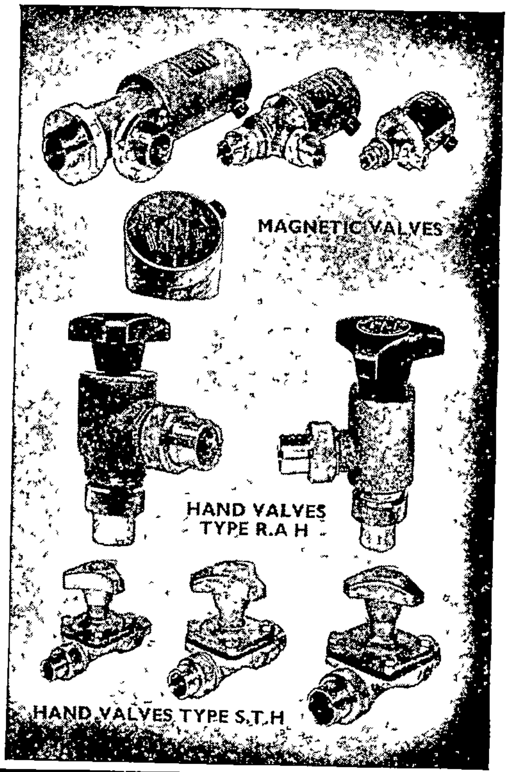

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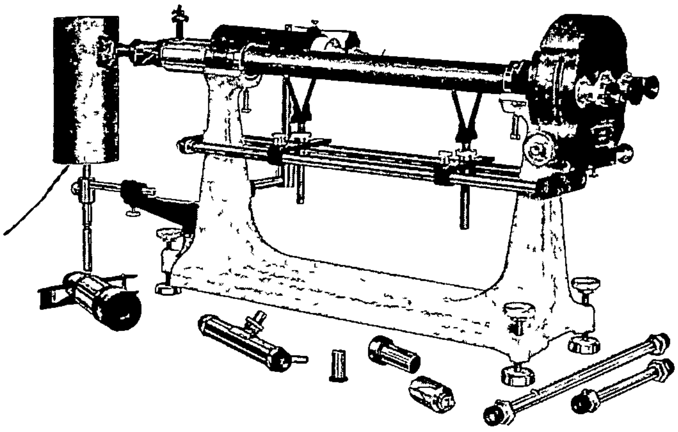

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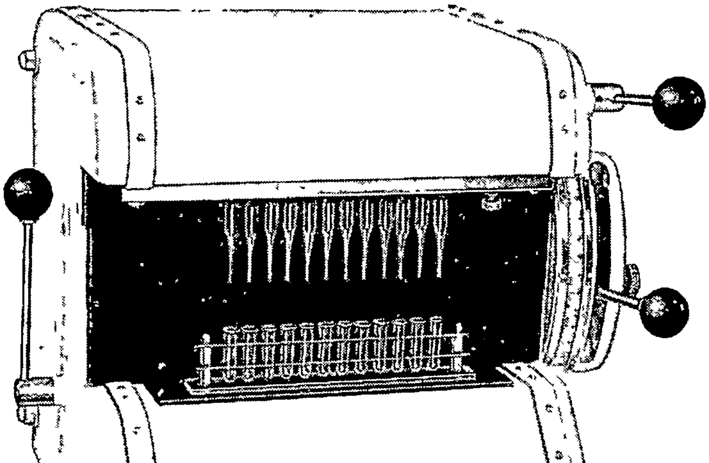

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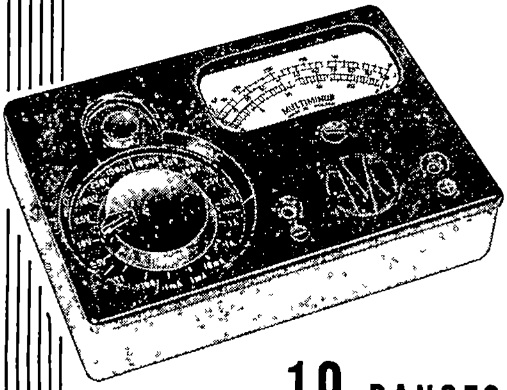

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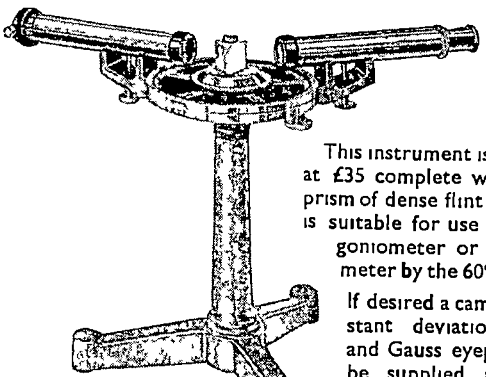

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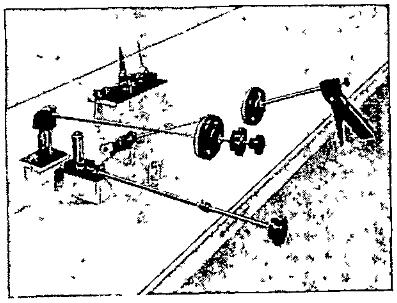

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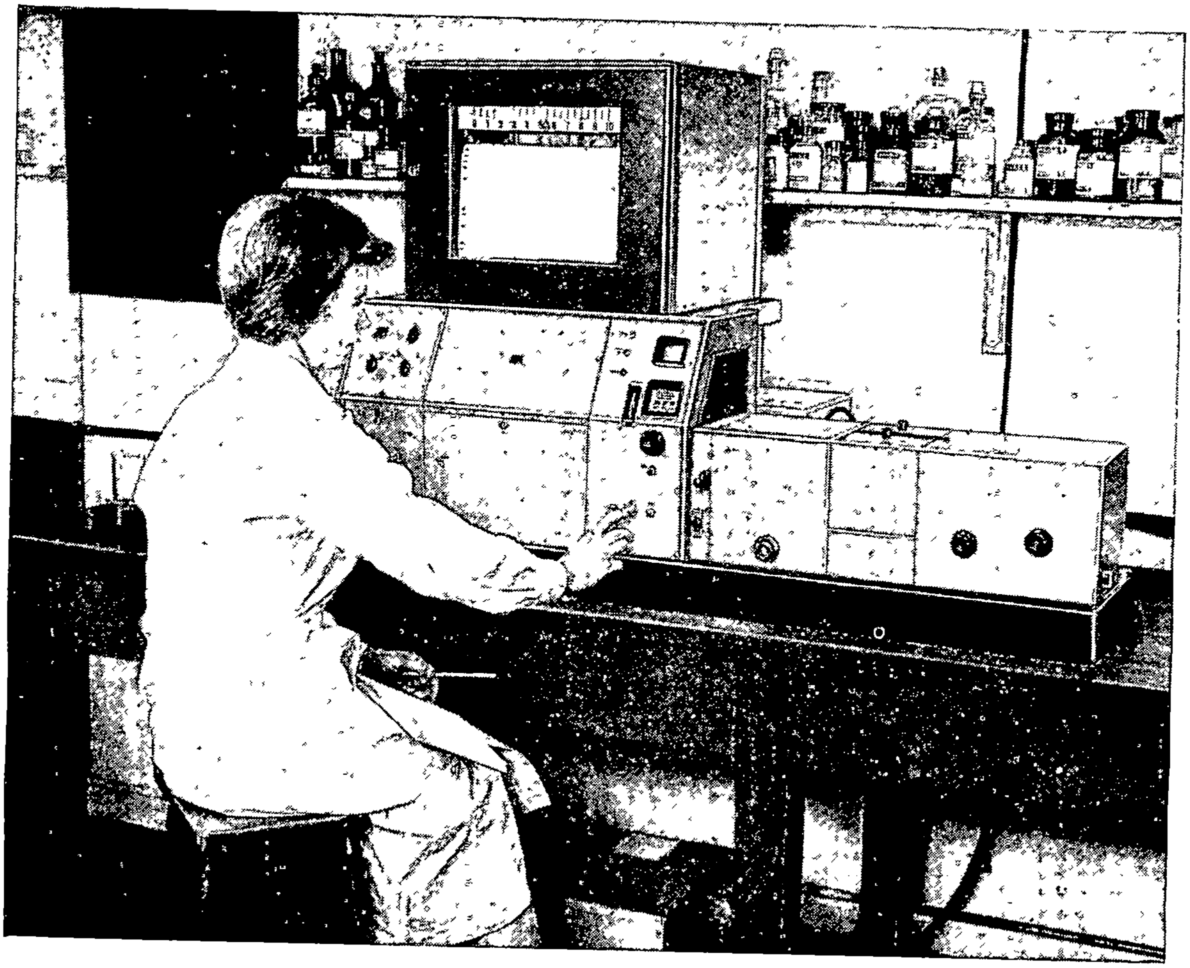

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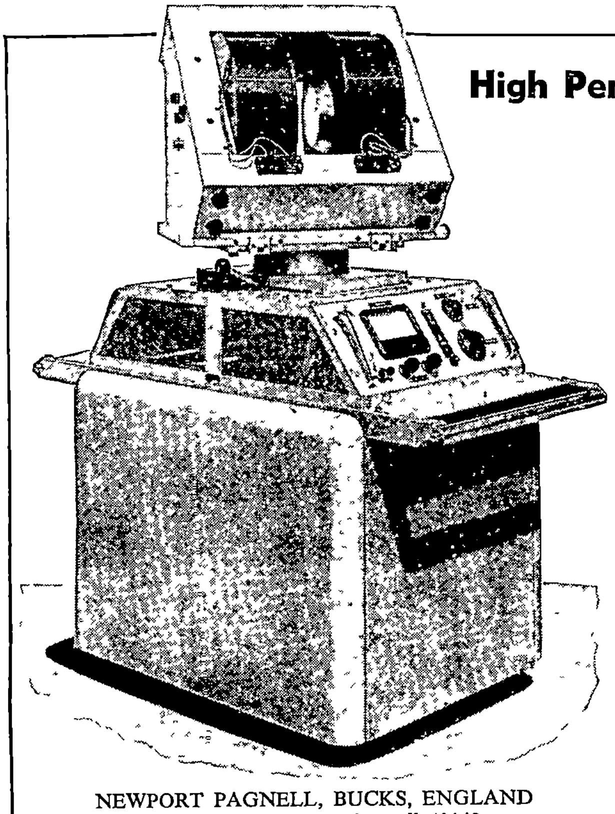

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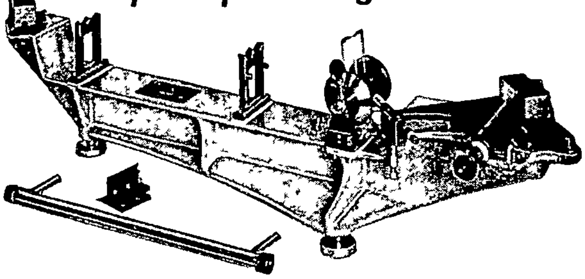

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NATURE

No 4691 SATURDAY, SEPTEMBER 26, 1959 Vol. 184

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FUNDAMENTAL RESEARCH IN BRITAIN

IT is well known that there has for some time been a serious conflict of opinion as to whether Britain should undertake a programme of space research Such a project has been strongly supported by some scientists and, as would appear from the tenor of his replies to questions on the subject in the House of Commons, is also favoured by the Minister of Supply Other scientists, however, are doubtful as to Britain's ability to spend sufficient resources on such a project to obtain a worth-while return without adverse effects on our scientific effort in other fields It has also been manifest from comments in the House of Commons that there is a strong body of opinion decidedly opposed to Britain entering on any such project merely because Russian and American scientists have done so, without the most careful consideration both of the probable return and the likely effect on our research effort elsewhere

The programme disclosed in the Prime Minister's statement in the House of Commons on May 12 seems unlikely to alarm those concerned about its effect on research effort generally Mr Macmillan said specifically that, while he could not give any figure for the cost of using a British rocket should it be decided to do so, all we are now doing is to spend a substantial but modest sum—hundreds of thousands of pounds rather than millions—first, for the design of the instruments, and secondly, for making the necessary designs for modifications of the American rocket, should it be decided when the time comes to use that vehicle Mr Macmillan said that he had asked the Lord President of the Council, in consultation with the Minister of Supply and other Ministers concerned, to exercise general supervision of these new developments

In repeating the Prime Minister's statement in the House of Lords on May 12, Lord Hailsham said that he had had very much in mind from the outset the correct deployment of our financial resources in different scientific spheres If he thought that what was now being done was in any way a rival to cancer research, or even that cancer research was being held up for purely financial reasons, he might take a different view He did not regard these two projects as rivals and thought that the merits of research projects should be examined in the light of hopeful leads and available personnel, rather than in terms of mere cash

That is clearly the right view to take and will be accepted by scientists generally The Prime Minister said there are two problems to be considered in relation to a British contribution to space research the nature and design of the instruments to be carried into space, and the vehicles in which these instruments are to be launched As to the first, with the assistance of Fellows of the Royal Society and with the endorsement of the Advisory Council on Scientific Policy, a programme for the design and construction of instruments to be carried in Earth satellites had been approved and work would begin at once

With regard to the second, Mr Macmillan said there might well be scope for joint action with the United States, with the Commonwealth or with other countries, and that a team of experts, including Prof H S W Massey, was being sent to Washington to discuss possible Anglo-American co-operation We are also opening consultations with other Commonwealth countries, and meanwhile design studies are being put in hand for the adaptation of British military rockets This would put us in a position, should we decide to do so, to make an all-British effort

On May 29 it was announced that Lord Hailsham had appointed a steering group on space research, under the chairmanship of Sir Edward Bullard This group—which includes Prof W V D Hodge, secretary of the Royal Society, Prof H S W Massey, Sir Harry Melville and the Astronomer Royal, and is subject to the responsibility of the Lord President of the Council, in consultation with the other Ministers concerned with the supervision of the Government's space research programme—"is to advise on the formulation of that programme and to co-ordinate the arrangements for its execution"

In replying to questions on his statement on May 12, the Prime Minister added that the instruments programme would be supervised by the British National Committee on Space Research set up by the Royal Society and under the chairmanship of Prof Massey He was certain that, in the field of scientific instruments, Britain should play her part in advancing the scientific effort In view of the importance of research in outer space he would probably use the appropriate moment at any 'Summit meeting' to discuss the desirability of a system of co-ordination and pooling of information with the Soviet Government The discussions with the United States were to be concerned with the possibility of some joint organization for the actual launching of the container for the instruments

In the House of Lords, Lord Hailsham dealt with this matter of international co-operation in replying to several supplementary questions Viscount Alexander of Hillsborough and Lord Rea urged the importance of keeping space research on an international basis as much as possible, and Lord Hailsham said that the Government has this aspect very much in mind He pointed out that both the Americans and the Russians, as well as ourselves, are co-operating in the Committee for Space Research, known as Cospar, a non-Governmental scientific body of the executive board of which Prof Massey is a member The United Nations Assembly last autumn set up an *ad hoc* committee to report to the next Assembly on the area of international co-operation in the peaceful uses of outer space which could appropriately be undertaken under United Nations auspices and the future organization of arrangements to facilitate such co-operation Great Britain and the United States, but not the U S S R, are co-operating with this Committee The Commonwealth as a whole is co-operating with both these international bodies and the Government is already inquiring of the Commonwealth countries what their contribution could be to the project announced by the Prime Minister

On this occasion Lord Rea urged the Government not to undertake too much, and Lord Hailsham's assurance that our scientific resources would not be dissipated was doubtless in response to this remark as well as to Lord Amwell's specific question about cancer research The trend of these developments, however, must have been known to Lord Hailsham when he spoke at the annual dinner of the Institution of Chemical Engineers on April 28, and his remarks on that occasion about the office of the Lord President of the Council are of the greatest interest in view of the wider responsibilities which the Lord President has now assumed and of which he was then presumably aware

Quoting Sir Hugh Beaver's remarks, Lord Hailsham agreed that the relation between government and science requires more attention than it is receiving and also that we are very far from arriving at the ideal solution—if, indeed, one exists—but he pointed out that the Lord President of the Council is not, and makes no claim to be, the head of British scientific thinking and planning Lord Hailsham did not think there could ever be any such person, but he naturally declined to speculate in public as to whether the Lord President has either the time or the means to discharge the duties laid upon him Such questions he obviously thought were worth asking and it could be taken that his remarks were designed to provoke discussion.

First, he questioned the wisdom of asking for "one coherent policy" on science, pointing out that science is not a subject but a whole thicket of subjects, some separate, some closely inter-related, but all animated by a common attitude of mind, and each contributing to a common corpus of knowledge Secondly, science cannot be abstracted from life, which it touches at every point If it is to play its part in industry or in government, it cannot be abstracted from them and then re-injected in a concentrated form Industries, including individual firms, need to be more scientifically minded, as do governments, including individual departments and ministers, but it would never be enough, however much time or means he had at his disposal, to have a single Minister responsible for the whole scientific field Such a Minister could never be a substitute for Ministers of Power, of Education, of Transport, etc, each of whom sought himself and through his staff to apply scientific techniques and knowledge to the problems of his office

For these reasons Lord Hailsham thought that what is wanted is not a new Minister or a new Ministry, but a new attitude on the part of the nation, the Government, industry and trade unions, in which each in his own sphere becomes more scientifically minded This, said Lord Hailsham, is "a continuation of the process which has been revolutionizing life on this planet for the past hundred and fifty years, and involves a more intelligent understanding of the forces at work To treat the problem thus as essentially one of education, Lord Hailsham admitted, will not answer any of the questions about the relation between Government and science, between education, research, industry and finance, or about the office of the Lord President, and he then discussed these relations more particularly

First, he emphasized that if the educational world and the scientific world are to perform their functions they must retain complete integrity and a high degree of independence This is essential even in the schools, and while the function of government in education is not easily defined, Lord Hailsham believed that the social value of an educational system depends on the curriculum remaining within the competence of the teaching profession As a matter of history, government entered the scientific sphere because no one else would do so on a sufficient scale, and this was now also true of education Nevertheless, Lord Hailsham urged that precisely because government plays, and undoubtedly would continue to play, a vital part as a patron of science, scientific decisions should be so far as possible in the hands of scientists Where it is practicable it is also desirable that they should draw on independent sources of finance, not in place of Government contributions but in addition to them Moreover, the direction of scientific policy should not be wholly in the hands of Government, but industry should be determined at every level to maintain its influence in its proper field of applied science and technical education, both by finance and by active participation both in its own and even in government-sponsored bodies, and this influence should be felt in the formation of policy and in the allocation of scientific man-power

Lord Hailsham's thesis is one that will commend itself to the scientist generally, and it is apparent from a paragraph in the last annual report of the Federation of British Industries that an important section of industry is prepared to undertake such responsibilities A detailed study of certain aspects of British research practice in relation to methods adopted abroad is already being made, so as to facilitate a detailed statement of industry's view of the Government's plans for industrial research as put forward by the Lord President's office Co-operation in technical education is also developing

Nevertheless, the thesis ignores the practical difficulty of deciding what is a scientific decision and what is a political decision Moreover, political decisions are liable to determine the resources available for scientific projects, both in terms of finance and of man-power This is well illustrated in the recent decision on space research It is the high cost of such research that is responsible for any concern with which the decision to enter that field may be regarded among scientists Great Britain has no margin for waste of scientific man-power or other resources, and it will be a prime concern of the Lord President and of Sir Edward Bullard and his steering group to see that Britain's limited effort is concentrated on the most profitable areas of research

Lord Hailsham showed clearly enough that he regards the Lord President of the Council as in some sense a Minister of research, though with the responsibility of a patron rather than of an overlord He pointed out that, measured by cost, most Government research is carried out under the Minister of Supply or by the Atomic Energy Authority, for which the Prime Minister is now directly responsible In the Civil Estimates for 1959–60, for example, expenditure on research and development is put, in round figures, at £270 million, of which £214 million is on the Ministry of Supply's vote, compared with £12 million for the Department of Scientific and Industrial Research, £3 5 million for the Medical Research Council and £4 5 million for the Agricultural Research Council This total, however, takes no account of whatever proportion of the £58 million for the universities which may be spent on research, or of the £92 million for the U K Atomic Energy Authority, which may go for research and development, though the estimates show that, of the last figure, £3 5 million is spent on research and development contracts with industry, the universities, etc

Even when it is remembered that the universities are still responsible for the larger part of Britain's effort in scientific research, these figures show that the Minister of Supply is too interested a party to be an entirely impartial adviser as to the expediency of a British space research programme Moreover he is also largely responsible for advising the Government as to the desirability of undertaking another costly long-term project—the development of a supersonic transport aircraft For the past two years a committee of leading aircraft designers and experts from the Royal Aircraft Establishment, Farnborough, has been studying the technical possibility of developing and building a supersonic air-liner, and if so, advising as to its optimum size, shape and speed

Lord Hailsham suggested that the present arrangement works satisfactorily although it may not be ideal Nevertheless, it should be noted that, in throwing on the Minister of Supply the responsibility for final recommendations in these matters, he is largely made judge in his own cause, and in one where the criteria are as essentially scientific as financial or economic It should also be remembered here that those who, like Prof A C B Lovell or Sir Harold Spencer Jones, have urged that Britain cannot afford to remain outside this new field of space research have done so on scientific grounds They are disturbed about the effect parsimony might have on our economic welfare and national well-being We depend indeed on our skill in manufacture, our ability to apply science and technology to the fullest possible extent, but we depend also on our ability to produce the new knowledge from which scientific and technical advance continually spring

Prof Lovell, in his Reith Lecture last year, specifically stressed benefits which mankind has reaped from fundamental scientific investigations carried out for their own sakes, and supported without thought of practical gain The programme of space research projected in the United States appears to comprise schemes for radiocommunication over great distances and for weather forecasting It also seeks to obtain data about the density and composition of the Earth's upper atmosphere, about the nature of interplanetary gas, the magnetic field of the Moon and the nature of the solid surface of Venus The tentative programme announced by the Prime Minister seems to offer scope for limited but worth-while experiments, and the ingenuity required to build the instruments for the satellites should be a valuable stimulus to the scientific instrument industry generally

If the programme is recognized as a reasonable compromise, the question of balance is nevertheless of great importance, and it has still to be shown that it will contribute anything essential to developing or extending the environment in which creative science flourishes We cannot argue that the project will help to retain promising scientists in Britain, without inquiring whether the prospects and opportunities in other scientific and technical fields are sufficiently attractive to keep them here This means something more than the assessment of priorities, or consideration of whether the Government is sufficiently alive to its responsibilities in other fields of research where considerations of high cost have, as Lord Hailsham admitted, made its entry imperative Biology and medicine have been specifically mentioned by critics of the present proposal, and in spite of what was said of cancer research in the House of Lords, progress in both these fields is regarded by some as gravely hampered by lack of funds

It is in this context that the whole organization of research in Britain is important, and independently of the merits of the space research programme, fuller investigation is undoubtedly needed into the returns that can be expected from investment in research in particular fields It may well be asked, as a question of economic survival, whether we can afford to spend about ten times as much on defence research as on pure and applied research generally, and whether everything possible is being done to avoid duplication of effort or waste of resources

The criticisms which were made by Mr Stanley Mayne, general secretary of the Institution of Professional Civil Servants, at the Institution's annual conference at Folkestone on May 25 may seem to refer to comparatively minor points, but nevertheless they indicate that the organization of research needs a little more consideration than Lord Hailsham was inclined to admit Mr Mayne welcomed the decision on space research and the 70 per cent increase in the expenditure of the Department of Scientific and Industrial Research, but was highly critical of certain decisions taken by the Council for Scientific and Industrial Research, particularly its failure to consult the directors of research laboratories in reaching major decisions concerning the future of those laboratories Mr Mayne asserted that there had also been no consultation with the advisory bodies of scientists associated with these laboratories, and pointed out that such failures in consultation or co-operation are liable to engender a spirit of frustration among the scientists concerned, whether they are on the staff of the laboratories or on the advisory bodies He also said that frustration is developing in the atomic energy research organization through a similar failure to consult with the staff or to explain the purpose of changes in organization

Mr Mayne's charges are essentially of bad management rather than of mistaken policy, and it is, of course, true that weakness in administration can be fatal in recruiting staff of high ability and enthusiasm Such defects, however, do not necessarily arise out of the structure of research organization unless it is seriously overloaded, but these criticisms lend some support to the suggestion put forward in the May issue of the Institution's journal, *State Service*, that the powers of the Lord President of the Council should be extended and that he should give more or less full time to his scientific responsibilities Lord Hailsham's speech to the Institution of Chemical Engineers seems to imply that this would be more in line with his own thinking than the creation of a Ministry of Science The further suggestion that consultation between individuals and bodies concerned with science should be improved also seems to agree with his views

Lord Hailsham might have reservations as to how far it is possible to frame precise recommendations as to the proportion of national resources which should be devoted to the training of scientists, scientific research and the application of scientific knowledge and the results of research to the national welfare, but he is undoubtedly concerned to stimulate co-operation and consultation and, above all, constructive thought as to how the scientific effort of Britain should be organized and what range of problems it is desirable to investigate It should be noted that he referred specifically to the contribution which professional bodies such as the Institution of Chemical Engineers could make to the formulation of policy and to the dependence of progress in technology on partnership between government, teaching bodies, research scientists and industry The value of such co-operation was stressed, from a different point of view, by Dr P F R Venables, principal of the College of Technology, Birmingham, and by Mr J J Gracie, chairman of the Governing Body, at the associateship presentation ceremony on April 25, both of whom referred to its importance in recruiting first-class teachers for the colleges of technology and in maintaining the conditions of service, including research, which would attract such men and women Lord Hailsham's address should stimulate both the constructive thinking and the close co-operation in all such matters which the launching of a British space research programme makes even more imperative, as it does also the need to consider our research effort as a whole and to keep it in balance with the man-power resources and varied needs of the nation

ORIGINS AND METHODS OF THE SCIENCES

Studies in the History and Methods of the Sciences By Arthur David Ritchie (Edinburgh University Publications History, Philosophy and Economics, 2) Pp vi+230 (Edinburgh The University Press, 1958 Distributed by Thomas Nelson and Sons, Ltd , 1958) 12*s* 6*d* net

FEW professional philosophers can have had Prof A D Ritchie's long, intimate and diverse acquaintance with science or rather, as he would rightly insist, with the sciences, since (in his words) "singular SCIENCE is the Sacred Cow of twentieth century idolatry" Chemistry and philosophy at St Andrews were followed by the Natural Sciences Tripos at Cambridge, then by four years as chemist with the Naval Airship Service during the First World War Next came two years' return to philosophy, then seventeen years in physiology and biochemistry in the Medical School at Manchester, before he turned whole-time to philosophy Perhaps when he retires from the chair of logic and metaphysics in the University of Edinburgh he will find occasion now and then to turn back to his early love of marine biology and comparative physiology In any event, he is singularly well qualified to write such a book as this his scientific friends will welcome the product of his multiple interests and critical thought

But others, too, will read it with appreciation, sympathy and attention for Ritchie's long concern with the sciences, their methods and their philosophy, is coloured by a broad humanity, and by a deep reverence which shows itself in a frankly religious approach to ultimate problems Lest such reverence be misunderstood, misunderstanding, as he writes, "has nearly always come of supposing that there are sacred *things*, whereas we know directly only of sacred *relations*" But Ritchie's humanity and reverence do not lead him to compromise with nonsense Marxists will not like this book, nor those infected with "the common error of supposing that physics is the one and only science", nor any biologists whose attitude is rooted still in the simplicities of nineteenth century physics

But to many others it will give much pleasure and enlightenment, particularly to those, like the present reviewer, who are sadly ignorant of the origin, history and philosophy of the sciences—if not of their methods, and to any who do not believe too piously that the secretions of the Sacred Cow can cure at once all human maladies, it will bring frequent and wholesome laughter It covers in a remarkably short space the origin of geometry, astronomy, chemistry via alchemy, biology in many aspects, 'human order' and cosmologies and it leaves no doubt of its author's conclusion that all these sciences, including mathematics, were derived originally from observation and experience, from the practical arts That does not mean, as he insists, that an even greater part in their development was not played by intellectual curiosity, by bold and critical thought, by trying to find order amid disorder but the order to be found was among real things, thrown up by measurement, by construction, by working metals, by observing the sky and the seasons, by breeding plants and animals and by medicine

The natural sciences to-day, and the technologies based on them, are taking an ever-growing part in human affairs, and apart from major disaster the growth will certainly continue But unless the process is critically watched and wisely guided a sort of chain reaction might set in, which could end in science and technology taking charge and leading man—who knows where ? It is vitally important, therefore, that thoughtful people of every kind should know something of the origins, the methods and the motives of the sciences, that in fact an enlightened public opinion should be formed the intelligent and humane cannot hope to guide if they do not understand at all So a world of good might be done if this book were widely read and discussed A V Hill

SCIENCE AND LITERATURE

The Scientific Background

A Prose Anthology By Prof A. Norman Jeffares and M Bryn Davies Pp xii+306 (London Sir Isaac Pitman and Sons, Ltd , 1958) 21*s* net

THE purpose of this book is two-fold to demonstrate to science students the precision and lucidity of the best scientific writing, and to offer to arts students and to the general reader a pleasant means of entry into the world of science The authors have fulfilled their first aim but have left the second in doubt Certainly the book is pleasant enough and should take its place as one of the most useful of recent bed-side books The intention of the authors is admirable, necessary and timely They point out the difficulties of the communication of scientific discoveries and ideas both because of the development of terminologies and professional jargon and the general deterioration in the ability to use language as a precise instrument The authors show that good scientific prose is good English prose and certainly give pointers towards a closing of the gap between science and arts

There are several ways of regarding the "background of science" The phrase has been used to describe the philosophy, the methodology, the sociological implications and the history of science The authors have chosen the literary background, but it still remains true that a great deal of communication in science remains mathematical and diagrammatic , thus, the fundamentally important problem of the semantics of communication theory in science is not explored

Within the limits of the pages at their disposal the authors have dealt with a part of the problem Those who expect a documentary history of science or even a series of readings in chronological order will be disappointed

The introduction is brilliantly written it should be read and learnt by every student of arts and science and everyone who is interested in education "The most pressing educational problem of the moment is how to remedy the broad divergence brought about by specialization between the two main branches of knowledge, the sciences and the humanities"

The substance of the book consists of a hundred short extracts of diverse types and purposes The first half dozen on writing are of great value Thereafter, there is an intriguing mixture The Krakatoa sunsets by the poet Gerard Manley Hopkins rubs shoulders with "Mathematics and Beauty" by C A Coulson Among extracts from the literature of the more common grammar school and university sciences we find "How to Climb the Turret of King's College Chapel, Cambridge" , Hoyle v Dingle and Dingle v Hoyle , James Kirkup's poem "A Correct Compassion" on a heart operation All these make an interesting *mélange* Some of the passages are too short and scrappy to have more than a sampling value Since the language of science cannot be divorced from its aims and methods, some longer passages, on the lines of Sir Cecil Dampier's "Cambridge Readings in the History of Science", would be useful

Sir Isaac Newton on the Law of Gravitation requires more than a page, and Faraday's wonderfully lucid "Chemical History of a Candle" demands a long extract, otherwise we do not see enough of the canvas on which he paints to obtain any idea of the whole picture

The book concludes with a number of questions which relate to each of the passages These should provide a useful basis for further analysis and discussion W L Sumner

TOXÆMIA AFTER BURNING

L'Auto-Intoxication après Brûlure

Par R Godfraind Pp 191 (Bruxelles Editions Arscia S A , 1958) n p

THE general effects of extensive burning are so profound and complex that it is not surprising that an all-embracing concept of toxæmia or auto-intoxication was put forward many years ago The idea, which apparently originated from Avdakoff in 1876 in St Petersburg, implied that toxin(s) formed in the skin after burning are absorbed into the circulation and may produce illness and death , but the number and variety of the 'toxins' which have been reported over the years in the blood, urine or burned skin are legion and indicate its elusive nature The hypothesis at one time led to the treatment of burns by tanning, which was said to precipitate the altered skin proteins and prevent absorption of their degradation products , but the tannic acid form of treatment itself produced 'toxic' effects and tanning is now discredited The concept of toxæmia has lost ground, first, through increasing knowledge of the hæmodynamic nature of burn 'shock', oligæmia and its relationship to the inflammatory exudation into the burned area , and secondly, through the recognition of the importance of bacterial infection of the burned surface and subsequent bacterial invasion of the body which can certainly produce the clinical picture of toxæmia Nevertheless, a number of important observations on burns remain unexplained, including the experimental observation reported originally by Wilson and his colleagues in Edinburgh that the œdema fluid from the burned skin of rabbits developed lethal properties for other rabbits and mice This aspect of toxæmia has been experimentally pursued by Simonart and Godfraind in Louvain Dr Godfraind's monograph is an account of their work on the role of proteins and their degradation products in burn toxæmia

The first part is concerned with the toxicity to frogs of heated fibrinogen and serum albumen, their peptic and plasmin hydrolytic products and with the composition of the œdema fluid in burned frogs The theme is developed in the second part of the book, which is concerned with studies in the rabbit on the toxicity of peptides, particularly when given subcutaneously, and an account of the pathology produced , with the œdema provoked by injection of peptides and its comparison with burn œdema fluid The toxicity of burn œdema fluid for other animals is confirmed, and this is related to protein fractions, particularly the euglobulin part of the exudate The whole process is said to be triggered-off by the activity of skin and other proteases after burning which, by the splitting of tissue and other proteins to polypeptides, induce local œdema , the exudation of plasma proteins follows, some of which become altered and are toxic on absorption

The author tries to account for the renal, gastro-intestinal, adrenal and other changes after burning on the basis of a peptide-induced toxæmia, but the argument is weak He greatly underestimates the parts played by oligæmia in producing the acute illness of burns, and also of bacterial infection and septicæmia The monograph contains useful material on the biological properties of proteins and their split-products, much of which is relevant to the recent work of Miles, Wilhelm, Spector and their colleagues in Britain on the role of blood proteins and polypeptides in the pathogenesis of acute inflammation The book is well produced , it has a summary in English and regard is paid to the work of others, including British workers

S SEVITT

DIFFERENTIAL EQUATIONS FOR INSTRUMENTATION ENGINEERS

Ordinary Differential Equations

By Dr Wilfred Kaplan (Addison-Wesley Series in Systems Engineering) Pp xv+534 (Reading, Mass Addison-Wesley Publishing Company, Inc , 1958) 8 50 dollars

THIS book can be used as a standard text-book on differential equations, for it covers much the same ground as, for example, Piaggio's well-known work , but it is intended particularly for students of instrumentation engineering, so that applications to servo-mechanisms, computers and controls are emphasized, and technical terminology is frequently employed Thus for the linear equation $F(D)\,x = f(t)$, the function $f(t)$ is termed the input, and if the complementary function (the solution for zero input) tends to zero with the time, the equation is said to be stable, the complementary function is a transient, and the complete solution is effectively represented by a particular integral, termed the output This phraseology is probably more graphic and so more easily appreciated by the student of control engineering than the familiar but flat language of the pure mathematician It also emphasizes the role of the differential equation as a functional transform from input to output, and so links up with the modern transform calculus The author keeps well in view the idea that the proper question to ask about a differential equation is not whether it can be solved but how much does it tell us about the function which satisfies it

Existence theorems are not ignored, but are placed at the end of the book and so need not obstruct a first reading Much of the material is classical and need not be specified here, but for more recent work there is a good section on matrices and their connexion with linear differential equations, and a most helpful introduction to the phase-plane method for non-linear equations The student who is daunted by the concentrated stimulus of Lefschetz or the high abstract precision of Coddington and Levinson might do well to play himself in through these chapters in Kaplan's book

In a book of 500 pages, to devote only 14 to numerical methods is derisory , there should be either a great deal more, or nothing save the half-page of references Simultaneous linear equations with constant coefficients occupy much space, but the methods given seem to be generally more awkward than Routh's efficient procedure There is nothing about modern operational or transform methods, save two or three pages on the application of the Laplace transform to constant-coefficient linear equations, too sketchy to be of value either to the ignorant or to the informed But this omission is fully explained by the author's promise of a speedy appearance of his companion volume on operational methods for linear systems

T A A BROADBENT

FERROELECTRICITY

Ferroelectricity in Crystals

By Helen D Megaw Pp xi+220 (London Methuen and Co , Ltd , 1957) 27*s* 6*d* net

FERROELECTRICITY is a subject of relatively recent origin, which is, at the moment, developing with exceptional rapidity The number and range of original papers are a constant strain on the time of investigators in the field, and must be bewildering to beginners These circumstances call for a skilful review of the subject, and this has been admirably accomplished by Dr Megaw in "Ferroelectricity in Crystals" This is a short book (only 220 pages), but by careful selection, logical arrangement, and lucid exposition the author has produced a volume which can be both a 'source book' to the expert and an introduction to the beginner

The first chapter gives a brief outline of the subject, with clear definitions of the new terms involved The following six chapters summarize the experimental data on Rochelle salt, potassium dihydrogen phosphate, barium titanate, other perovskite materials, and miscellaneous structures such as cadmium niobate and guanidine aluminium sulphate hexahydrate The remaining three chapters expound the present theoretical position, including the thermodynamic method of correlating observed properties, and the basic features of current theoretical models of ferroelectrics

The approach to the problem is essentially crystallographic, and the object of bringing out the close correlation between the structure, and the intrinsic electric properties of the single domain is successfully achieved The treatment gains in clarity by making only brief reference to domain dynamics, with its murky problems of failing memories and fictitious surface layers

The book has a short, well-chosen index, and a most useful glossary of crystallographic terms There are copious references to original papers throughout the text, which are listed at the end of each chapter

Altogether this is a book of exceptional merit, and it is only to be hoped that demand proves sufficient to allow further editions to be produced at not too long intervals

L E CROSS

ROLE OF THE SCHOLAR IN SOCIETY*

By Dr HENRY ALLEN MOE

Secretary-General of the John Simon Guggenheim Memorial Foundation, President of the American Philosophical Society

RALPH WALDO EMERSON, who made it, declared that a scholar's first duty in society is not to quit his belief that a popgun is a popgun, although the ancient and honourable of the Earth affirm it to be the crack of doom. It is all there, all that anyone needs to know about the function of the scholar in society in these days, or in any days: you go where your evidence takes you; and there you stand, even though the ancient and honourable of the Earth are sure that you should be standing somewhere else.

But in this modern world—the world in which the Newtonian mechanics, to cite but one example, have been shown to have less than the divinity which hedged them about for centuries—I conceive that the Emersonian declaration needs a Moeian rescension: "Neither shall the scholar quit his belief that the crack of doom is the crack of doom, although the ancient and honourable of the Earth affirm it to be a popgun."

Of the need for this rescension, there are many examples; and in view of the fact that this is the centenary of the publication of Charles Darwin's "On the Origin of Species", I shall refer first to that crack of doom for much of theology and more of biology. The first edition of that book, all 1,200 copies, was sold out, it is true, in less than a day; but then the wielders of the popguns began to pop.

An article in *The Quarterly Review* said that Darwin was attempting in his book "to prop up his utterly rotten fabric of guess and speculation" and declared that it was all "utterly dishonourable to science". *The Spectator* accused Darwin of collecting a mass of facts to substantiate a false principle. Darwin's own college, Trinity at Cambridge, would not permit a copy of the "Origin" in its library. Sir John Herschel, the astronomer, described Darwinism as "the law of higgeldy-piggeldy". Darwin's old geology professor at Cambridge, Sedgwick, wrote to Darwin that the book was "false and mischievous" and added that when he read it had "laughed till his sides ached".

But there were defenders, too: T. H. Huxley, Charles Lyell, geologist, Asa Gray, American botanist, the last-named contradicting his colleague Agassiz at Harvard. The end of the pros and cons is not yet in sight; but, undoubtedly, it was not a popgun that Darwin fired off, although many of the ancient and honourable of the Earth were strongly of that opinion.

Moreover, there was Dante of the thirteenth and fourteenth centuries, in some ways the greatest mind of all time, who, as Oliver Goldsmith put it clearly and accurately, "first followed Nature and was persecuted by his critics as long as he lived"—in and out of exile and in and out of prison. Sick with petty quarrels and dissensions, Dante strained the eyes of his mind toward the hills, for the appearance of a universal monarch who should be raised above the flaws of faction and the spur of political ambition, under whom each country, each city, might (under the institutions best suited to it) lead the life and do the work for which it was best fitted. United in spiritual harmony, Dante showed to the world for the first time a plan of a government where the strongest force and the highest wisdom were interpenetrated by all that God had given to the world of piety and justice; and it is not possible to say that Dante's dream did not work its own realization nor to deny that the high ideal of the poet had its effect. For, five centuries later, it became embodied in the constitution of the Italian State, which still has no stronger bond of union than a common worship of the exiled and imprisoned poet's indignant and impassioned verse[1].

But I need not multiply my examples: everyone will have those that are better and clearer for himself, because they flow from his own fields of interest. Nevertheless, for me there still remains to relate the poignant example of Edward FitzGerald's translation—which is more than a translation—of "The Rubaiyát of Omar Khayyám". The centenary of its publication has been scarcely observed. It appeared in April 1859 for sale at 1*s*. a copy. But it found not one buyer at that price; and all 250 copies of the first edition were remaindered at 1*d*. each.

Omar, a son of the tentmaker, was, in his lifetime, famous as philosopher, astronomer and mathematician. He was one of the eight astronomers appointed by the eleventh-century Persian Malik Shah to reform the calendar; and as FitzGerald has him say in his verses (for 'Rubáiyát' simply means verses):

> "Ah, but my Computations, People say
> Reduced the Year to better reckoning? Nay,
> 'Twas only striking from the Calendar
> Unborn Tomorrow and dead Yesterday."

Omar's contemporaries honoured him for his mathematical and astronomical computations; but, for his verses, they denounced him as a free-thinker. The "Rubáiyát", in essence, is a plea for tolerance: in it, everything is tolerated except intolerance. This point of view was offensive to orthodox Muslims. As was said in "The Book of Learned Men", an Arabic biographical work of the thirteenth century: "The inner meanings [of Omar's verses] are as stinging serpents to the Musselman law; hence, the men of his day hated him. . . ."

Being disapproved in contemporary eleventh-century Islam, the verses lay in obscurity on through the ages. So small was their interest that only two manuscripts have been found—one in the Bodleian Library of the University of Oxford, and one in the Library of the Asiatic Society of Bengal in Calcutta.

The resistances which the eleventh-century Omar's verses met in Islam were no different in kind from the resistances which the FitzGerald translation met in nineteenth-century Christendom So it was that Edward Cowell, the Persian scholar who had introduced FitzGerald to the "Rubáiyát" manuscripts, wrote that he would not permit a book on the Omar verses to be dedicated to him "I unwittingly incurred", he said, "a grave responsibility when I introduced his poems to my old friend I admire Omar but I cannot take him as a guide"[2]

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* Substance of an address delivered on May 21 at the Rockefeller Institute Convocation for Conferring of Degrees and Dedication of New Buildings (see also *Nature* of June 13, 20 and 27, 1959).

In the pre-Darwinian Western world, when all things were known or could be known by revelation —especially about human affairs—words such as these by Omar had no takers

> "There was the Door to which I found no Key ,
> There was a Veil through which I might not see "

But Omar had seen clearly that the great questions always stand—*all* the great questions of literature and history and philosophy and science stand—outside the limits of finality It is a lesson we have not learned to this day To cite an example, from a field in which many of you must tread more familiarly than I—an example which I have from that very great mathematician, Hermann Weyl—as late as 1923 the writers on relativity theory and tensor calculus were accused by some of the ancient and honourable of the Earth of having laid waste a rich cultural domain, that rich cultural domain being the algebraic theory of invariants This time, what was called a popgun truly became the crack of doom

But a new key, which the ancient and honourable of the Earth had not found, was found in the theory of representations of continuous Lie groups , and by these new means the old problems which, according to the complaint, the relativists had let go by the board have been attacked on a much deeper level than was possible by the algebraic theory of invariants[3]

There still is a "Veil through which I might not see", still a "Door to which I found no Key" , but the Veil and the Door are different veils and different doors, placed further down the corridor of men's eternal quest for Truth

> "Of all sad words of tongue or pen" [wrote our
> own Whittier],
> "The saddest are these, it might have been"

One is tempted to wonder, in the most futile of wonderment, as I know, what might have happened in Islam as well as in Christendom, in the Middle East as well as in the West, if the freedom-giving intellection behind Omar Khayyam's "Rubáiyát" had become as well understood as Charles Darwin's intellection "On the Origin of Species"

But let me not engage in speculative futility on this occasion Rather, let me hope with Omar, for each one of us, that

> "Of my base metal may be filed a Key
> That shall unlock the Door he [the Dervish] howls
> without"

"A Hair, perhaps, divides the False and True", wrote Omar in the eleventh century A hair, perhaps, divides the popgun from the crack of doom, the crack of doom from the popgun The function of the scholar in any society is to make that division for himself and then to stand on the side of the divide that represents truth for him

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[1] "Encyclopædia Britannica", eleventh edit , in article "Dante"

[2] "The Life of Edward FitzGerald", by Alfred Mckinley Terhune, 218 (1947)

[3] "Relativity Theory as a Stimulus in Mathematical Research", by Hermann Weyl, *Proc Amer Phil Soc* (1949)

LYMAN-ALPHA PHOTOGRAPHS OF THE SUN

By J D PURCELL, DR D M PACKER and DR R TOUSEY
U S Naval Research Laboratory, Washington 25, D C

SPECTRA photographed from rockets by the University of Colorado[1,2] and by the U S Naval Research Laboratory[3] have shown that the Lyman-alpha line of hydrogen, λ1215 7A , is emitted by the Sun with high intensity Little beyond this is definitely established concerning the details of the emission Values of half-width vary between 1 A , reported by Miller *et al* [2], and not more than 0 3 A , published by Johnson *et al* [3] The total intensity of Lyman-alpha during the recent years near the sunspot maximum has been found by Byram *et al* [4] to be 5–6 ergs/cm ^{2} sec , on a number of rocket flights Whether the much lower values recorded earlier near sunspot minimum were correct is controversial

The first Lyman-alpha photographs of the solar disk were obtained by Mercure *et al* [5] in 1956 Each of the four images obtained showed three regions where the density was approximately 0 03 greater than the scattered white-light background This blackening was attributed to Lyman-alpha radiation and was found to agree, approximately, in position with the three principal areas where plages were located in calcium *K* and hydrogen-alpha spectroheliograms Low resolution and prominent grain made further correlations impossible, and the limb of the Sun was not sharply defined

A new series of Lyman-alpha images of the Sun was obtained from an *Aerobee-Hi* rocket between 15 47 5 and 15 48 5 U T on March 13, 1959 The altitude ranged from 110 to 170 km , which was sufficiently high to be above appreciable atmospheric absorption at this wave-length Simultaneously, the Sun was photographed in white light, hydrogen-alpha and calcium *K* The Mount Wilson, McMath-Hulbert and Sacramento Peak Observatories, the Naval Observatory and the Naval Research Laboratory co-operated in this programme

Fig 1 shows a diagram of the instrument, described by Purcell[6] It is essentially a double monochromator, using two 40-cm radius gratings with 600 lines per mm in the first order, arranged so that the dispersions are additive The Lyman-alpha image of the Sun formed by the first grating is passed by an aperture in a diaphragm which intercepts the rest of the spectrum The second grating disperses the light again, forming a Lyman-alpha image enlarged by a factor of 2 and freed from stray light The first grating was mechanically deformed, as described by

Purcell and Tousey[7] in such a way as to produce a stigmatic image. One grating was coated with aluminium plus magnesium fluoride, the other with zinc sulphide, with specular reflectances at λ1216 A. of 80 per cent and 31 per cent, respectively, as described by Hass and Tousey[8]. As a result, the system was very fast and 1/50 sec. was sufficient to produce a good image. The entire unit was kept pointed at the Sun with a servo system constructed by the University of Colorado.

In Fig. 2 is reproduced one of the 1/50 sec. Lyman-alpha solar disk images. Presented for comparison are a calcium $K_{2,3,2}$ spectroheliogram obtained by the McMath–Hulbert Observatory, and a hydrogen-alpha$_{2,3,2}$ image photographed by the U.S. Naval Research Laboratory. Both were made while the rocket was in flight. The white-light photograph was made by the U.S. Naval Observatory at 13.57 U.T., on the same day. The axis of the Sun is vertical with north at the top and east at the right.

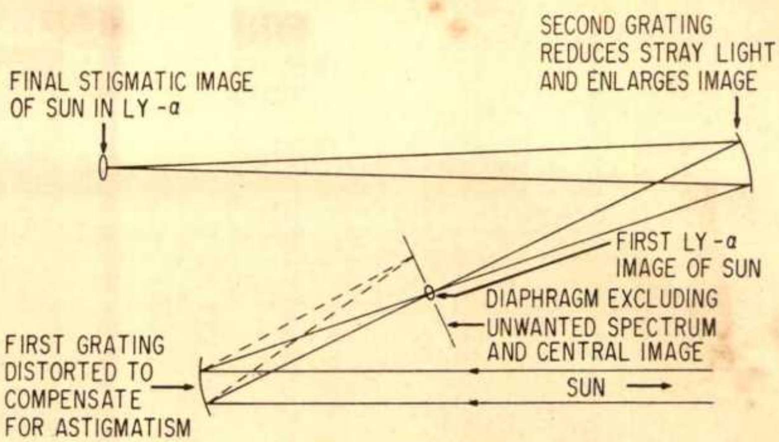
SECOND GRATING REDUCES STRAY LIGHT AND ENLARGES IMAGE
FINAL STIGMATIC IMAGE OF SUN IN LY-α
FIRST LY-α IMAGE OF SUN
DIAPHRAGM EXCLUDING UNWANTED SPECTRUM AND CENTRAL IMAGE
FIRST GRATING DISTORTED TO COMPENSATE FOR ASTIGMATISM
SUN

Fig. 1 Optical diagram of the Lyman-alpha camera

It is apparent that Lyman-alpha radiation is emitted most strongly from plages, and that the pattern of emission resembles calcium *K* more than

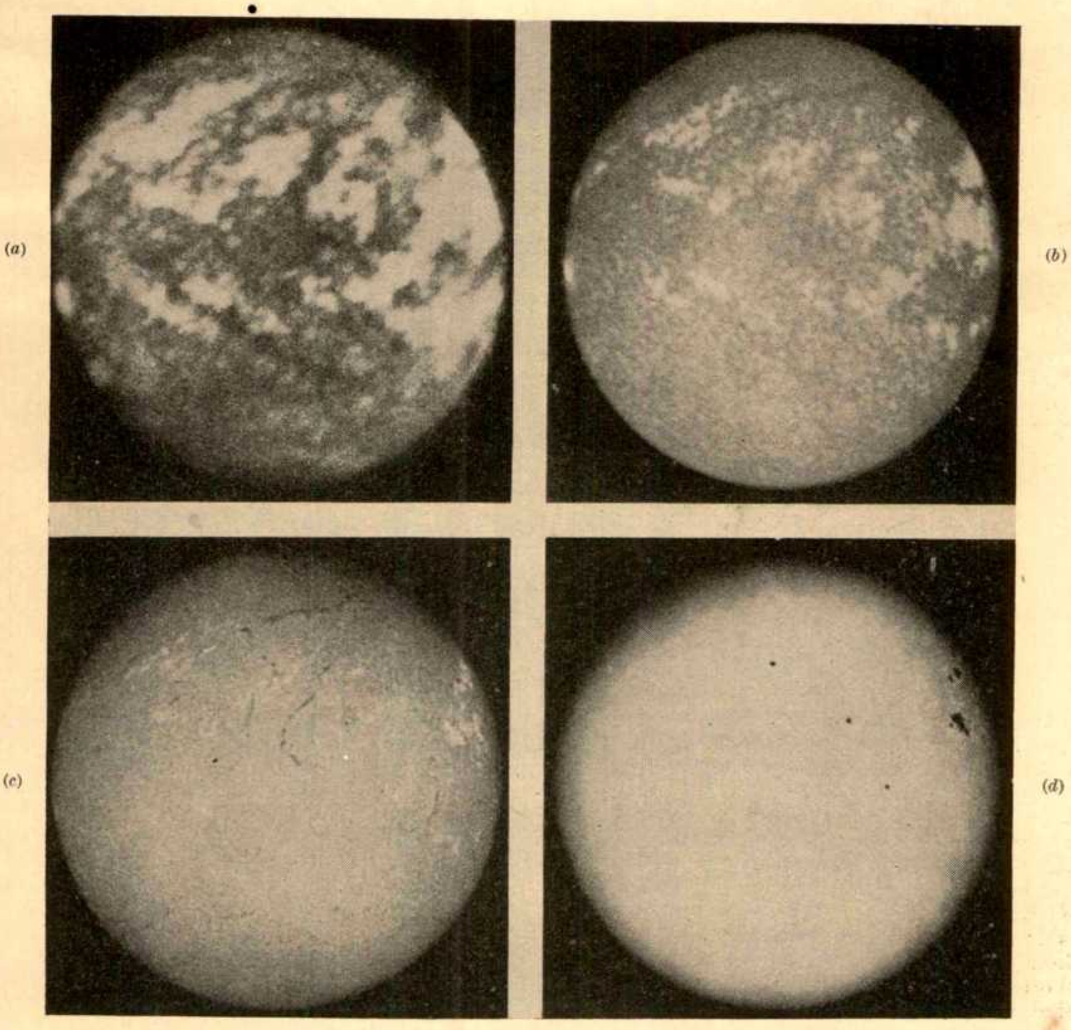

Fig. 2. Images of the Sun on March 13, 1959. (*a*) Lyman-alpha of hydrogen from *Aerobee-Hi* rocket; (*b*) calcium $K_{2,3,2}$ spectroheliogram (McMath–Hulbert Observatory); (*c*) hydrogen-alpha with 0·7 A. monochromatic filter (Naval Research Laboratory); (*d*) white light (U.S. Naval Observatory)

it does hydrogen-alpha radiation. The Lyman-alpha image differs from calcium *K* by having a larger ratio of intensity between bright and dark features, and by having a coarser structure.

The solar Lyman-alpha image in general shows detail down to about 1 min. of arc only; it is probable that this limit was set by the resolving power of the instrument. However, there is reason for believing that the coarseness of the pattern may, in part, be a real characteristic of the Lyman-alpha image, because the instrumental resolving power was found to be 1/3 min. in the laboratory, and because some details down to half a minute of arc appear in the solar image. The very fine stippling is, of course, photographic grain.

The correlation between features in the calcium *K* and Lyman-alpha images is striking. If the detail in the calcium *K* image is reduced to about the same as that present in the Lyman-alpha image, which can be accomplished by viewing the print out of focus, all the bright details in the two images match approximately.

The high contrast between Lyman-alpha plages and the background is quite noticeable. From preliminary measurements it appears that the ratio between the intensity of the brightest plage and the average inactive region is twice as great as in the corresponding regions of the calcium *K* image[9]. As a result, the Lyman-alpha plages seem to cover a larger fraction of the disk than the calcium *K* plages (observations furnished by courtesy of McMath–Hulbert Observatory). However, if the faintest calcium *K* plages are included, the difference in area covered is not great.

Conspicuous in the Lyman-alpha image are several broad dark lines. One follows the course of the calcium *K* filament in high northern latitudes. The most prominent dark line lies below the equator, at an angle of about 30° to it. This can barely be seen in the calcium *K* and hydrogen-alpha images. There is no corresponding well-defined filament in hydrogen-alpha and only a trace of a filament in calcium *K*. Such an outstanding feature cannot be attributed to a narrow filament alone, since a sharply defined narrow filament, when photographed at low resolution, would form a broad but extremely faint dark line.

The darkest part of the Lyman-alpha image is near the centre of the Sun. Limb darkening or brightening, in general, would be difficult to establish because of the complicated and varied pattern over the disk.

Most of the sunspots, shown by white light, do not appear in the Lyman-alpha image. The large group near the limb cannot be seen at all. The centre of the string of three, which is surrounded by a penumbra in the *K*-line image, is visible as a large hole in the corresponding Lyman-alpha plage. The upper of the three can also be seen.

The limb, as shown in Fig. 2, is clear-cut and real. In several of the long Lyman-alpha exposures, which are not reproduced here, prominences can be seen. The correlation with hydrogen-alpha prominences is good. The largest prominence seen in the Lyman-alpha radiation can be followed out to about 1 min. of arc from the limb, which is about the same as for the hydrogen-alpha image.

The high intensity and great extent of the Lyman-alpha plages suggest that the total intensity of Lyman-alpha radiation emitted by the Sun might be expected to depend on the extent of the plages. The total area covered by intense calcium plages reaches a maximum at sunspot maximum, and falls off to near zero at minimum. If the Lyman-alpha plages behave in a similar fashion, the Lyman-alpha emission intensity of the Sun should vary significantly between sunspot maximum and minimum.

[1] Rense, W. A. *Phys. Rev.*, **91**, 299 (1953).

[2] Miller, jun., S. C., Mercure, R., and Rense, W. A., *Astrophys. J.*, **124**, 580 (1956).

[3] Johnson, F. S., Malitson, H. H., Purcell, J. D., and Tousey, R., *Astrophys. J.*, **127**, 80 (1958).

[4] Byram, E. T., Chubb, T. A., Friedman, H., Kupperian, jun., J. E., and Kreplin, R. W., *Astrophys. J.*, **128**, 738 (1958).

[5] Mercure, R., Miller, jun., S. C., Rense, W. A., and Stuart, F., *J. Geophys. Res.*, **61**, 571 (1956), and private communication from Rense, W. A.

[6] Purcell, J. D., *J. Opt. Soc. Amer.*, **47**, 1057 (*SB*36) (1957).

[7] Purcell, J. D., and Tousey, R., *J. Opt. Soc. Amer.*, **47**, 1057 (*SB*35) (1957).

[8] Hass, G., and Tousey, R., *J. Opt. Soc. Amer.*, June (1959).

CONVERSION OF LIGHT INTO CHEMICAL ENERGY IN PHOTOSYNTHESIS

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THE discovery[1-3] in 1954 that isolated chloroplasts are capable of forming carbohydrates from carbon dioxide and water with a simultaneous evolution of oxygen, with no energy supply except visible light, has opened a way for investigating the central problem of photosynthesis, the conversion of light into chemical energy, in a physiologically viable system free from the structural and functional complexity of the whole cell. This approach has already forced a re-examination[4] of certain established concepts in photosynthesis. One of the most fruitful of these concepts in guiding contemporary research in photosynthesis, including the current work with isolated chloroplasts, has been the theory of van Niel[5] that photolysis of water is the basic reaction, common to green plants and photosynthetic bacteria, for converting light into chemical energy. However, very recent experiments[6-9] with isolated chloroplasts and cell-free particles of the photosynthetic sulphur bacterium, *Chromatium*, now suggest that photosynthetic phosphorylation rather than photolysis of water is the common denominator of photosynthesis in bacteria and in green plants. The purpose of this article is to trace the recent evolution of this alternative view of photochemical events in photosynthesis, and to present, in a unified fashion, some of the evidence and considerations on which it rests.

Separation of Light and Dark Phases of Photosynthesis in Green Plants

It has long been considered (literature cited in ref. 10) that carbon assimilation proper is a dark, chemosynthetic phase of photosynthesis, and that the reactions involved are, in all probability, not peculiar to photosynthesis but rather reversals of those responsible for the degradation of sugars in respiration[11] Support for this point of view is found in the recent identification by Trudinger[12] and Aubert *et al* [13] in the chemo-autotrophic, but non-photosynthetic, bacterium *Thiobacillus denitrificans*, of the same cyclic mechanism for carbon dioxide assimilation in the dark as is found in photosynthesis of green plants[14] Moreover, Racker[15,16] has recently obtained, in the dark, a synthesis of hexose phosphate from carbon dioxide by a multi-enzyme system consisting of glycolytic enzymes from rabbit muscle and yeast and the pentose cycle enzymes from spinach leaves In his experiments, the energy needed for this synthesis was supplied by including in the reaction mixture exogenous adenosine triphosphate and an enzymatic device for generating, in the dark, reduced diphosphopyridine nucleotide at the expense of added molecular hydrogen or alcohol

If the experiments of Racker are taken as a model for the dark carbon dioxide assimilation in photosynthesis by green plants. as was proposed by Calvin[14], then the essence of photosynthesis, the conversion of light energy into physiologically useful chemical energy, must lie in the photochemical reactions which generate adenosine triphosphate and reduced pyridine nucleotides at the expense of absorbed light energy Moreover, since the dark reactions responsible for carbon dioxide assimilation do not result in oxygen evolution—which remains a unique characteristic of photosynthesis in green plants—the photochemical phase of photosynthesis must account for the formation of three products oxygen. reduced pyridine nucleotide and adenosine triphosphate

In the intact cell, the conversion of light into chemical energy is closely bound with carbon dioxide assimilation, the light and dark phases of photosynthesis are closely interwoven, and attempts to separate them experimentally have so far yielded no effective method for investigating the mechanism of the photochemical reactions Thus, when whole cells were pre-illuminated in the absence of carbon dioxide they were shown to acquire in light only a short-lived capacity, measured in seconds[17] or minutes[18,19], for a subsequent dark carbon dioxide fixation There was no agreement as to the chemical nature of this transient and unidentified product of the light reaction Calvin *et al* [19] characterized it as a "reducing power" whereas Gaffron *et al* [17] considered it to be an acceptor substance for carbon dioxide fixation Likewise, with respect to adenosine triphosphate, experiments with whole cells have given no clue as to the mechanism and site of adenosine triphosphate formation in photosynthesis In general schemes for photosynthesis, adenosine triphosphate required for carbohydrate synthesis was usually assumed to come from oxidative phosphorylation by mitochondria (see, for example, ref 20 (Fig 7), and also review, ref 21)

A special contribution of experiments with isolated chloroplasts to the study of the mechanism of photosynthesis is that they have provided an effective experimental approach to the separation of the light-dependent phase of that process, in which oxygen, reduced triphosphopyridine nucleotide and adenosine triphosphate are formed, and the dark phase during which carbon dioxide is assimilated A physical separation of the two phases of photosynthesis by fractionating chloroplasts has recently been described by Trebst *et al* [10] The light phase was completed first by the complete chloroplast system in the absence of carbon dioxide and resulted in an evolution of oxygen accompanied by an accumulation of reduced triphosphopyridine nucleotide and adenosine triphosphate in the reaction mixture The green portion of the chloroplasts (grana) was then discarded, and when carbon dioxide was next supplied to the remaining non-green portion of the chloroplasts (stroma) in the dark, it was assimilated to sugar phosphates The two phases, when carried out separately, yielded, essentially, the same final photosynthetic products as the continuously illuminated chloroplast system The conclusion seemed justified, therefore, that the conversion of absorbed light energy into the chemical energy used for carbon dioxide assimilation in the dark occurs during the photochemical reactions in which chloroplasts evolve oxygen and form assimilatory power[4], that is, adenosine triphosphate and reduced triphosphopyridine nucleotide These two substances are then, so far as it is now known, the first stable chemical compounds formed by green plants at the expense of absorbed light energy and are thus the true 'first products of photosynthesis', a term which has usually been applied to products of carbon dioxide fixation, such as phosphoglyeracte[14]

Photochemical Reactions in Cell-free Systems

The three products of the light reactions in chloroplasts, oxygen, adenosine triphosphate and reduced triphosphopyridine nucleotide, are now known[4,22] to be formed by two reactions*

$$\mathrm{ADP} + \mathrm{H_3PO_4} \longrightarrow \mathrm{ATP} \qquad (1)$$

$$\mathrm{2TPN} + \mathrm{2H_2O} + \mathrm{2ADP} + \mathrm{2H_3PO_4} \xrightarrow{\text{reductase}} \mathrm{2TPNH_2} + \mathrm{O_2} + \mathrm{2ATP} \qquad (2)$$

A non-physiological variant of reaction 2 is reaction 3, in which triphosphopyridine nucleotide is replaced by ferricyanide (represented here by Fe^{3+})

$$\mathrm{4Fe^{3+}} + \mathrm{2H_2O} + \mathrm{2ADP} + \mathrm{2H_3PO_4} \longrightarrow \mathrm{Fe^{2+}} + \mathrm{O_2} + \mathrm{2ATP} + \mathrm{4H^+} \qquad (3)$$

Reactions 1 and 2 revealed a previously unknown capacity of chloroplasts to use light energy for the formation of the energy-rich pyrophosphate bonds of adenosine triphosphate, a process called photosynthetic phosphorylation to distinguish it from oxidative phosphorylation by mitochondria[23], formerly known to be the only cytoplasmic particles capable of forming adenosine triphosphate Photosynthetic phosphorylation of the kind shown in reaction 1, in which adenosine triphosphate is the sole product of absorbed light energy, has been designated as cyclic photophosphorylation[4] to distinguish it from the non-cyclic photophosphorylation shown in reaction 2, in which only part of the light energy absorbed by chlorophyll is used for the formation of adenosine triphosphate, the remainder is used for the formation of a reductant, reduced triphosphopyridine nucleotide, which provides the 'hydrogens' needed for the conversion of carbon dioxide to sugars (Non-cyclic photophosphorylation has also been called "one-step"[4] or "primary" photophosphorylation[24-26])

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* The following abbreviations will be used TPN or TPN_{ox}, $TPNH_2$ or TPN_{red}, oxidized and reduced forms of triphosphopyridine nucleotide, ADP, ATP, adenosine di- and tri-phosphopyridine nucleotide, Fe^{3+} cyt, Fe^{2+} cyt, oxidized and reduced forms of cytochrome, FMN_{ox}, FMN_{red}, oxidized and reduced forms of riboflavin phosphate, PN, PNH_2, oxidized and reduced forms of pyridine nucleotide, P, orthophosphate

Non-cyclic photophosphorylation (equation 2) provides all the three expected products of the light phase of photosynthesis in green plants molecular oxygen and the two components of assimilatory power required for the conversion of carbon dioxide into sugars reduced triphosphopyridine nucleotide and adenosine triphosphate Cyclic photophosphorylation (equation 1) supplies only adenosine triphosphate and the participation of this reaction in carbon dioxide assimilation would be needed only if the adenosine triphosphate formed in reaction 2 were insufficient for carbon dioxide assimilation to the level of carbohydrate—a conclusion for which, as will be shown later, there is now experimental evidence

Of the two photochemical reactions of isolated chloroplasts, the less-versatile one, cyclic photophosphorylation, was the more interesting from the point of view of possible mechanisms of energy transformations in photosynthesis Cyclic photophosphorylation (equation 1) permitted us to view the key event of photosynthesis, the conversion of light into chemical energy, as being unrelated to the two corner-stones of photosynthesis in green plants the reduction of carbon dioxide and the evolution of oxygen Instead of producing a reductant for carbon dioxide assimilation, reaction 1 converts the absorbed light energy into a general species of cellular energy, adenosine triphosphate, a highly negotiable physiological "energy currency" which can be used for a multitude of endergonic reactions within the cell[27]

The significance of cyclic photophosphorylation as a general energy conversion process in photosynthesis was greatly increased when it became clear that the structural association of chlorophyll pigments with a phosphorylating system is not limited to green plants but is apparently found in all photosynthetic cells and constitutes a fundamental aspect of photosynthesis[4] Soon after photosynthetic phosphorylation was observed in chloroplasts, Frenkel[28,29] demonstrated photosynthetic phosphorylation in cell-free preparations of a purple, non-sulphur photosynthetic bacterium, *Rhodospirillum rubrum*, a finding confirmed by Geller[30,31] and Mattick and Lindstrom[32] Williams[33], Kamen and Newton[34], and Anderson and Fuller[35] described a photosynthetic phosphorylation in the chromatophores[36,37] of the obligately anaerobic photo-autotroph, *Chromatium*

The photosynthetic phosphorylation found in bacterial chromatophores was of the cyclic type As would be expected from the anaerobic nature of bacterial photosynthesis, chromatophores were unable to carry out non-cyclic photophosphorylation in which the formation of adenosine triphosphate is accompanied by oxygen evolution (equation 2 or 3) Cyclic photophosphorylation appeared, therefore, as a fundamental process, common to all photosynthetic organisms, by which light energy is converted into chemical energy It seemed reasonable to expect that elucidation of the mechanism of cyclic photophosphorylation would prove important to the understanding of the energy conversion process in photosynthesis

Cyclic Photophosphorylation in Chloroplasts and Chromatophores

The first working hypothesis proposed[3] for the mechanism of cyclic photophosphorylation attempted to account, within the framework of van Niel's hypothesis of photolysis of water[5], for several experimental observations The capture of light energy by chloroplasts was not accompanied by oxygen evolution[3,38 39] (or absorption) and was independent of carbon dioxide assimilation[1–3], no reductant was formed or oxidized as a substrate[3,40], the process was (in addition to Mg^{2+}) strongly catalysed by added riboflavin phosphate, vitamin K substances and ascorbate, but not by pyridine nucleotides[3 38,41]

The first hypothesis[3] proposed, visualized cyclic photophosphorylation as resulting in the simultaneous generation, through a photolysis of water, of a reducing agent (H) and an oxidizing agent (OH) at opposite ends of an electron transport chain Vitamin K, riboflavin phosphate, ascorbate and cytochromes were tentatively proposed as members of the electron-transport chain which catalysed a stepwise recombination of the products of photodecomposition of water, thereby making energy available for the formation of pyrophosphate bonds The role of the first electron or hydrogen acceptor was tentatively assigned[3] to either riboflavin phosphate or, as proposed by Wessels[42], to vitamin K

The inadequacy of this hypothesis became apparent when further studies of cyclic photophosphorylation indicated that there are two kinds of cyclic photophosphorylation in chloroplasts Maximal rates of cyclic photophosphorylation occurred with either riboflavin phosphate or vitamin K as catalysts At a saturating concentration of one catalyst, the addition of the other gave no further increase in photophosphorylation, but little phosphorylation occurred unless one of them was added

Riboflavin phosphate and vitamin K appeared to catalyse separate pathways for the electron (or hydrogen) transport which results in cyclic photophosphorylation[26,43,44] The riboflavin phosphate and vitamin K pathways, types or "systems", as they will often be referred to, were found by Whatley *et al* [26,43] to be similar in their requirement for Mg^{2+} and ascorbate, their sensitivity to certain inhibitors such as *p*-chloromercuribenzoate and gramicidin and their insensitivity to others, for example, arsenite and antimycin *A* The two pathways for cyclic photophosphorylation differed, however, in that the riboflavin phosphate system was more sensitive to inhibition by *o*-phenanthroline and dinitrophenol than the vitamin K pathway[26,43] Moreover, triphosphopyridine nucleotide, which was in the meantime found to be a catalyst of cyclic photophosphorylation[45], appeared to be required for the riboflavin phosphate pathway but not for the vitamin K system[26,43] The association of the riboflavin phosphate pathway with triphosphopyridine nucleotide was also indicated by the finding that the non-cyclic photophosphorylation with triphosphopyridine nucleotide (equation 2) was as strongly inhibited by *o*-phenanthroline and dinitrophenol as was the cyclic photophosphorylation with riboflavin phosphate[26,43]

Bacterial chromatophores were found to have only the vitamin K pathway of cyclic photophosphorylation The addition of riboflavin phosphate and triphosphopyridine nucleotide was found to be without effect[7,30] Cyclic photophosphorylation in bacterial chromatophores[30,34] as well as in chloroplasts[46] is also known to be catalysed by a non-physiological agent, phenazine methosulphate This process, in both chloroplasts and chromatophores, was found to resemble the vitamin K system in being resistant to inhibition by *o*-phenanthroline and dinitrophenol and independent of triphosphopyridine nucleotide[7,26] The common denominator of photo-

Table 1 EFFECT OF CHLORIDE ON PHOTOSYNTHETIC PHOSPHORYLATION BY ISOLATED CHLOROPLASTS (ref 6)
(μmoles phosphate esterified)

Phosphorylating system	− Chloride	+ Chloride
(*A*) Non-cyclic, ferricyanide	0 3	3 7
(*B*) Non-cyclic, TPN	0 7	3 6
(*C*) Cyclic, riboflavin phosphate	2 4	7 4
(*D*) Cyclic, vit K$_3$	7 3	8 7
(*E*) Cyclic, phenazine methosulphate	8 3	8 3

In all treatments the reaction mixture (3 ml total volume) contained, in μmoles *tris*(hydroxymethyl)aminomethane (adjusted to *p*H 8 2 with acetic acid), 80, adenosine diphosphate, 10, K$_2$HP^{32}O$_4$, 10, magnesium sulphate, 5 Special additions in the respective treatments were (*A*) ferricyanide, 8 μmoles, (*B*) triphosphopyridine nucleotide, 4 μmoles, chloroplast extract (ref 45) (CE) equivalent to 2 mgm chlorophyll, (*C*) riboflavin phosphate, 0 1 μmole, triphosphopyridine nucleotide, 0 3 μmole, sodium ascorbate, 5 μmoles, (*D*) vit K$_3$ (menadione), 0 3 μmole, sodium ascorbate, 5 μmoles, (*E*) phenazine methosulphate, 30 μgm 'Broken' chloroplasts free of chloride (ref 6) and containing 0 25 and 0 1 mgm chlorophyll were added to the non-cyclic and cyclic systems, respectively 10 μmoles potassium chloride were added to the 'plus chloride' treatment Gas phase, nitrogen Illumination, 30 min in all treatments, except (*E*) illuminated 15 min Other methods are described elsewhere (ref 40)

synthesis in chloroplasts and chromatophores could thus be narrowed down specifically to the vitamin K type of cyclic photophosphorylation

Role of Chloride

Fresh support for the existence of separate pathways for electron transport in photosynthetic phosphorylation has come from the recent work of Bové *et al*[6] on the role of chloride in photosynthesis Warburg[47] discovered that chloride, replaceable by bromide but not by other anions, was essential for oxygen evolution by isolated chloroplasts This discovery was fully confirmed by Arnon and Whatley[48], but they were disinclined to accept, at that time, Warburg's conclusion that chloride is a coenzyme of photosynthesis, because this conclusion would have conferred on chloride the then unwarranted status of an essential element for green plants However, they envisaged the possibility[48] which has since been documented[49,50], that chloride may prove to be an essential micronutrient for green plants

A re-investigation[6] of the role of chloride in the photochemical reactions of chloroplasts (Table 1) confirmed Warburg's conclusion that chloride is essential for photosynthesis in green plants Chloride was found to be required for the non-cyclic photophosphorylations (equations 2 and 3) and for the riboflavin phosphate pathway of cyclic photophosphorylation, all three reactions being known to occur only in chloroplasts Chloride was not required, however, for the vitamin K pathway of cyclic photophosphorylation[6] which is the only type of photophosphorylation shared by bacterial particles and chloroplasts Thus, in the absence of chloride, chloroplasts behaved like bacterial chromatophores, they were able to carry out only the vitamin K pathway of cyclic photophosphorylation

Mechanisms of Cyclic Photophosphorylation

If it is accepted that the vitamin K pathway of cyclic photophosphorylation represents the simplest common denominator of photosynthesis in green plants and bacteria, then a mechanism for this reaction would be expected to provide a basic pattern for the conversion of light into chemical energy The salient facts which must be explained are that a "high-energy" pyrophosphate bond is formed at the expense of absorbed light energy There is no need, *a priori*, to connect this reaction with either photolysis of water or reduction of carbon dioxide Cyclic photophosphorylation produces neither a reductant for carbon dioxide assimilation nor molecular oxygen, the sole product is adenosine triphosphate

The formation of adenosine triphosphate is a familiar biochemical process in all living cells[27] It is commonly encountered in glycolysis and respiration, in which the formation of the high-energy pyrophosphate bond occurs at the expense of energy released during the transport of electrons (or hydrogens) from an electron donor (substrate) to an electron acceptor In respiration the ultimate electron acceptor is molecular oxygen through a series of reactions which result in the formation of water

The simplest hypothesis to account for the formation of adenosine triphosphate in cyclic photophosphorylation is to assume that, as in the dark reactions of respiration, the formation of a pyrophosphate bond is also coupled with a release of energy during an electron transport process However, there is a basic difference between the two in that the electron transport in cyclic photophosphorylation occurs within a "closed", cyclic system from which electrons are not removed, as they are in respiration when they are finally accepted by oxygen In respiration the energy of a substrate has been consumed when it has donated its electrons to oxygen In cyclic photophosphorylation the "energy substrate" which is consumed is light The mechanism by which this is accomplished must therefore provide for a recurrent addition of energy by light to the electrons travelling within the "closed circuit" of cyclic photophosphorylation, thereby raising them to a high energy-level Phosphorylation would then occur at the expense of energy released during a "downhill" transport of the electron from a high to a low energy status in the course of its cyclic pathway A diagrammatic representation of this concept is given in Fig 1

These considerations lead to the following hypothesis for cyclic photophosphorylation The primary photochemical reaction is visualized as being of the photo-oxidation type studied by G N Lewis and his school, in which a light-absorbing molecule, in this instance chlorophyll (attached to a protein component), becomes "excited" and acquires a tendency to expel an electron as well as a capacity to accept one as a replacement for the electron which is being expelled The expelled electron is raised to a high-energy potential at the expense of the absorbed quantum of light energy The proposed hypothesis suggests that the light energy acquired in this manner is transformed into chemical energy in the course of the "downhill" return of the electron to the chlorophyll system via a series of enzyme systems which act as the "transformers" for converting light energy into chemical energy These enzymatic transformations constitute the energy conversion process in photosynthesis

The return of the electron restores the chlorophyll molecule to its ground-state, and the system is ready again to accept a light quantum and repeat the process Chlorophyll can, of course, also be restored to the ground-state when the expelled electron returns directly without going through the enzymatic "energy transformer stations", but in that case electron energy has not been converted into chemical energy and hence photosynthesis has not occurred Instead, a light quantum is emitted and the characteristic fluorescence of chlorophyll is observed

The primary photochemical reaction, in which an absorbed light quantum "excites" a chlorophyll

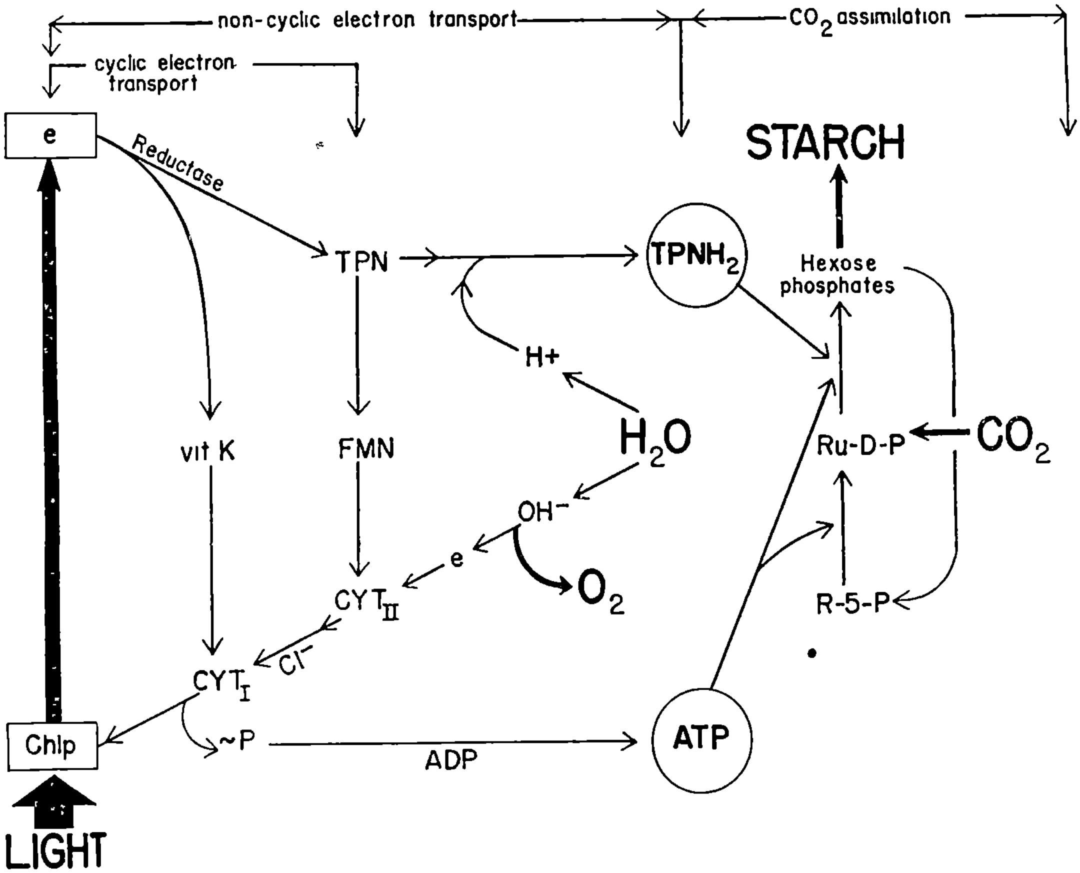

Fig. 1. Proposed scheme for photosynthesis. Chlorophyll, on absorbing a light quantum, becomes 'excited' and expels electrons which have been raised to a high energy-level. In both green plants and photosynthetic bacteria the energy thus acquired from the absorbed light is converted into the pyrophosphate bond-energy of adenosine triphosphate (ATP) during the 'downhill' return of electrons to chlorophyll by a cyclic electron transport system of the vitamin K type. In green plants there is a second cyclic electron transport system of the riboflavin phosphate (FMN) type for forming adenosine triphosphate and also an 'open', non-cyclic mechanism which transports electrons from chlorophyll to triphosphopyridine nucleotide (TPN). In the non-cyclic mechanism the electrons accepted by triphosphopyridine nucleotide are replaced by those donated to chlorophyll by OH$^-$ ions, with a resulting evolution of oxygen. Cytochrome (cyt) components are visualized in the electron transport chain of the cyclic and non-cyclic mechanisms. It is suggested that photosynthetic bacteria use light energy only for the formation of adenosine triphosphate by the vitamin K type of cyclic photophosphorylation. Green plants, however, require both the cyclic and non-cyclic electron transport systems for the formation of assimilatory power, that is, adenosine triphosphate and reduced triphosphopyridine nucleotide (TPNH$_2$). These two substances are then used for assimilation of carbon dioxide to the level of sugar and starch in a series of dark reactions involving the regeneration of ribose-5-phosphate (R-5-P) and ribulose diphosphate (Ru-D-P). Further details are given in the text

molecule and "expels" an electron is represented by equations 4 and 4*a*. The symbol (Chlp)$^+$ is intended to denote that the chlorophyll molecule as it expels an electron becomes ready to accept another and in this way returns to a normal state (cf. "odd ion"[51]).

$$\text{Chlp} + h\nu \longrightarrow \text{Chlp}^* \qquad (4)$$

$$\text{Chlp}^* = (\text{Chlp})^+ + \text{electron} \qquad (4a)$$

The observed cyclic photophosphorylation reactions of isolated chloroplasts and bacterial chromatophores are best explained by a hypothesis that the electron expelled in the primary photochemical reaction is restored to chlorophyll by one of two enzymatic pathways corresponding to the vitamin K and the riboflavin phosphate types of cyclic photophosphorylation. The path of electrons in each of the two pathways will now be traced separately (cf. Fig. 1).

In the vitamin K pathway, it is visualized that two electrons from reaction 4 (written below for schematic clarity as equation 4*b*) are transferred to an oxidized form of vitamin K, giving reduced vitamin K (equation 5). Reduced vitamin K is in turn oxidized by a cytochrome component (cyt$_I$), which may be different in green plants and photosynthetic bacteria but which is in both cases closely associated with the photosynthetic apparatus (equation 6). The cytochrome reduced in reaction 6 donates electrons to the excited chlorophyll from reaction 4, in a "terminal" reaction (equation 7) which restores the chlorophyll to its normal ground-level and produces an oxidized cytochrome. It is visualized that phosphorylation is coupled with the oxidation of this terminal cytochrome component in a manner analogous to the phosphorylations which accompany the oxidation of cytochromes by mitochondria[52].

$$2\,(\text{Chlp} + h\nu) \longrightarrow 2\,(\text{Chlp})^+ + 2\text{ electrons} \qquad (4b)$$

$$\text{Vit K}_{\text{ox}} + 2\text{ electrons} \longrightarrow \text{Vit K}_{\text{red}} \qquad (5)$$

$$\text{Vit K}_{\text{red}} + 2\,\text{Fe}^{3+}\text{cyt}_{\text{I}} \longrightarrow \text{Vit K}_{\text{ox}} + 2\,\text{Fe}^{2+}\text{cyt}_{\text{I}} \qquad (6)$$

$$2\,\text{Fe}^{2+}\text{cyt}_{\text{I}} + 2\,(\text{Chlp})^+ + \text{ADP} + \text{H}_3\text{PO}_4 \longrightarrow 2\,\text{Fe}^{3+}\text{cyt}_{\text{I}} + 2\,\text{Chlp} + \text{ATP} \qquad (7)$$

$$\text{Sum} \quad \text{ADP} + \text{H}_3\text{PO}_4 + 2\,h\nu \longrightarrow \text{ATP} \qquad (1)$$

The sum of reactions 4*b*, 5, 6 and 7 would result in a cyclic photophosphorylation as represented earlier by equation 1, in which light is the "energy-substrate" which is being consumed. It is quite possible that reaction 6, the oxidation of reduced vitamin K, is also coupled with phosphorylation, as was suggested by the model reactions proposed by Wessels[42], Harrison[53] and Clark, Kirby and Todd[54], thereby increasing the total number of phosphorylations which result from the cyclic transport of two electrons in the overall reaction 1

The proposed mechanism for the vitamin K pathway is regarded as the simplest pattern common to green plants and photosynthetic bacteria for converting light into a single form of chemical energy, an energy-rich pyrophosphate bond All other energy conversion reactions in photosynthesis would therefore be expected to be modifications of this basic design

If this basic postulation is correct, it follows that cyclic photophosphorylation should be abolished if the electrons are prevented from completing the cycle by a transfer to an external electron acceptor To be convincing, such an experiment should be carried out with an electron acceptor which would be free from the suspicion that it prevented phosphorylation by acting as an uncoupler, or in some toxic manner

An electron acceptor which fulfils these requirements is ferricyanide It does not uncouple or otherwise inhibit photophosphorylation since its reduction by illuminated chloroplasts is accompanied by a phosphorylation (equation 3) of the non-cyclic type[4,22] Moreover, as shown by Jagendorf[55] and confirmed in this laboratory, ferricyanide has a great affinity for electrons released during the illumination of chloroplasts Ferricyanide added to a vitamin K or phenazine methosulphate system becomes reduced and cyclic photophosphorylation is replaced by the non-cyclic type until all the ferricyanide has reacted

As was mentioned earlier, the non-cyclic photophosphorylation with ferricyanide (equation 3) requires chloride[6] In the absence of chloride, ferricyanide would still accept electrons from the illuminated chloroplast system, but non-cyclic photophosphorylation could not occur Thus by adding ferricyanide, in the absence of chloride, to a cyclic system of the vitamin K type which is independent of chloride, cyclic photophosphorylation should be inhibited if the proposed hypothesis is correct The cyclic transport of electrons in the closed circuit would be interrupted since the electrons would be removed from the system and used in the reduction of ferricyanide

Table 2 shows that this theoretical prediction has been experimentally verified The addition of ferricyanide abolished cyclic photophosphorylation both in chloroplasts[6] and in chromatophores[7] Adding this ion in its reduced form, as ferrocyanide, was without effect The reduction of ferricyanide with ascorbate either prior to or during illumination of the photosynthetic particles restored in full their capacity for cyclic photophosphorylation The conclusion seemed justified, therefore, that the inhibitory effect of ferricyanide resulted from the capture, by this ion in its oxidized form, of electrons which would have normally travelled the cyclic electron transport route (Fig 1) This conclusion was strengthened by the finding that the inhibition was produced by very low concentrations of ferricyanide This would be expected if, as demanded by the hypothesis, the capture of electrons from the cyclic system left its catalytic components in an oxidized form

Table 2 INFLUENCE OF CHLORIDE ON FERRICYANIDE INHIBITION OF CYCLIC PHOTOPHOSPHORYLATION BY SPINACH CHLOROPLASTS AND BACTERIAL CHROMATOPHORES (*Chromatium*) (refs 6, 7)
(μmoles phosphate esterified in 30 min)

Treatment	Chloroplasts −chloride	 +chloride	Chromatophores −chloride	 +chloride
Control	9 2	9 8	4 9	5 1
Ferricyanide				
1 μmole	0 5	9 1	0 4	0 3
2 μmoles	0 5	8 8	0 5	0 5
3 μmoles	0 5	8 7	0 4	0 4
Ferricyanide, 5 μmoles, reduced by ascorbate*	7 2	7 8	6 2	6 8
Ferrocyanide, 5 μmoles	9 4	9 7	5 4	5 1

* Sodium ascorbate (5 μmoles) was tipped in from a sidearm 15 min after the beginning of the experiment, and illumination was then continued for 30 min

In the chloroplast series the reaction mixture was the same as in the phenazine methosulphate treatment described in Table 1 except that 0 25 mgm chlorophyll was used In the chromatophore series (ref 7) the reaction mixture (final volume, 3 ml) contained dialysed *Chromatium* chromatophores (0 23 mgm bacteriochlorophyll) and dialysed extract, and the following in μmoles *tris*(hydroxymethyl)-aminomethane, *p*H 7 8, 80 , adenosine diphosphate, 10 , labelled potassium phosphate, *p*H 7 8, 10 , magnesium sulphate, 5 , vit K_3, 0 3 , and phenazine methosulphate, 0 1 The 'plus chloride' treatments received 10 μmoles potassium chloride Special additions as indicated Other experimental conditions as described in Table 1

The riboflavin phosphate type of cyclic photophosphorylation is visualized as a modification of the vitamin K type The electron expelled by light from chlorophyll in reaction 4 is also returned by a cyclic pathway but one which includes triphosphopyridine nucleotide and a second cytochrome component (Fig 1), in accordance with equations 8, 9, 10 and 11 The riboflavin phosphate (FMN) pathway is completed when the reduced terminal cytochrome component (cyt_I) formed in reaction 11 reacts with chlorophyll through reaction 7, as in the vitamin K pathway

$$2\ (\text{Chlp} + h\nu) \longrightarrow 2\ (\text{Chlp})^{+} + 2\ \text{electrons} \qquad (4b)$$

$$\text{TPN}_\text{ox} + 2\ \text{electrons} \xrightarrow{\text{reductase}} \text{TPN}_\text{red} \qquad (8)$$

$$\text{TPN}_\text{red} + \text{FMN}_\text{ox} \longrightarrow \text{TPN}_\text{ox} + \text{FMN}_\text{red} \qquad (9)$$

$$\text{FMN}_\text{red} + 2\ \text{Fe}^{3+}\text{cyt}_\text{II} \longrightarrow \text{FMN}_\text{ox} + 2\ \text{Fe}^{2+}\text{cyt}_\text{II} \qquad (10)$$

$$2\ \text{Fe}^{2+}\text{cyt}_\text{II} + 2\ \text{Fe}^{3+}\text{cyt}_\text{I} \xrightarrow{\text{Cl}^-} 2\ \text{Fe}^{3+}\text{cyt}_\text{II} + 2\ \text{Fe}^{2+}\text{cyt}_\text{I} \qquad (11)$$

$$2\ \text{Fe}^{2+}\text{cyt}_\text{I} + 2\ (\text{Chlp})^{+} + \text{ADP} + \text{H}_3\text{PO}_4 \longrightarrow 2\ \text{Fe}^{3+}\text{cyt}_\text{I} + 2\ \text{Chlp} + \text{ATP} \qquad (7)$$

$$\text{Sum} \quad \text{ADP} + \text{H}_3\text{PO}_4 + 2\,h\nu \longrightarrow \text{ATP} \qquad (1)$$

The sum of reactions 4*b*, 8, 9, 10, 11 and 7 would also bring about a cyclic photophosphorylation as represented by equation 1 According to this formulation the riboflavin phosphate pathway shares with the vitamin K pathway the primary photochemical reaction (equation 4) and the same site for phosphorylation (equation 7) By analogy with oxidative phosphorylation in mitochondria[52], the riboflavin phosphate pathway in chloroplasts might also result in additional phosphorylations coupled with reactions 9 and 10, resulting in more than one pyrophosphate bond formed per two electrons

It is postulated that reduced riboflavin phosphate cannot reduce directly the terminal cytochrome component needed in reaction 7 (cyt_I) but can do so only through the intermediary of a second cytochrome component (cyt_II) as shown in reaction 10 This postulation is necessary, since the riboflavin phosphate pathway is dependent on chloride, and, on present evidence[6], the effect of chloride can best be explained by assigning to this ion a catalytic function in a portion of a cytochrome electron transport chain which is represented by equation 11. The riboflavin phosphate pathway would also depend on the special reductase needed for the reduction of triphosphopyridine nucleotide[45,56].

Carbon Dioxide Reduction and Oxygen Evolution

Cyclic photophosphorylation provides the same basic mechanism for forming adenosine triphosphate at the expense of light energy for both green plants and photosynthetic bacteria. But cyclic photophosphorylation cannot, by itself, result in carbon dioxide reduction—it does not supply the necessary reductant. Moreover, the proposed mechanism for cyclic photophosphorylation makes no provision for the most distinctive feature of photosynthesis in green plants, the evolution of oxygen—a feature which distinguishes sharply between photosynthesis in green plants and in photosynthetic bacteria, where oxygen evolution does not occur[5].

In developing a general hypothesis for photosynthesis to embrace both green plants and photosynthetic bacteria there is a choice between two alternatives. One can, as van Niel did[5], postulate that the basic similarity between these two types of photosynthesis is the common photochemical origin of a reductant for carbon dioxide and the precursor for molecular oxygen. Van Niel proposed that the light reaction in both groups of organisms is a photolysis of water which results in the formation of a reduced and oxidized moiety, (H) and (OH). To account for the lack of oxygen evolution in bacterial photosynthesis van Niel pointed to the well-established requirement of this process for an external hydrogen donor. The external hydrogen donor was, in his postulation, required for reducing the (OH) back to water, and in this manner keeping the photosynthetic apparatus in bacteria functioning[5].

With the recognition of cyclic photophosphorylation as a process common to photosynthesis in green plants and photosynthetic bacteria, an alternative hypothesis is now possible which omits photolysis of water as the common photochemical reaction in photosynthesis. The alternative hypothesis proposed here considers oxygen evolution in green plants to result not from a photolysis of water but from an "open" non-cyclic electron transport mechanism which is peculiar to green plants. In photosynthetic bacteria a precursor of oxygen would not be formed, and hence there would be no need to postulate that the function of the external hydrogen donor in bacterial photosynthesis is to reduce a precursor of oxygen. According to the present hypothesis an external hydrogen donor is needed in bacterial photosynthesis to supply hydrogens (probably via pyridine nucleotides) for carbon dioxide reduction. In this view what is common to both types of photosynthesis is a mechanism for formation of adenosine triphosphate by a photochemical reaction; what is different is the manner of supplying the reductant for carbon assimilation. Oxygen evolution by green plants becomes merely a consequence of the special way in which they form reduced triphosphopyridine nucleotide in light.

Recent experiments of Ogata *et al.*[7] support the proposal that in photosynthetic bacteria the external hydrogen donor reduces pyridine nucleotides independently of light. Chromatophores isolated from *Chromatium* cells, grown with either thiosulphate or hydrogen gas as the external hydrogen donor, were found[7] to contain an active hydrogenase, capable of reducing pyridine nucleotides with molecular hydrogen in the dark. On the basis of present evidence, the similarities and differences in photosynthesis of green plants and bacteria (represented here, for the sake of simplicity, by *Chromatium* grown with hydrogen gas as the external hydrogen donor) can be summarized as follows:

PHOTOSYNTHESIS

	GREEN PLANTS	PHOTOSYNTHETIC BACTERIA (*Chromatium*)
LIGHT PHASE	*Cyclic photophosphorylation* $ADP + P \longrightarrow ATP$ *Non cyclic photophosphorylation* $2TPN + 2H_2{}^{*}O + 2ADP + 2P \longrightarrow 2TPNH_2 + {}^{*}O_2 + 2ATP$	*Cyclic photophosphorylation* $ADP + P \longrightarrow ATP$
DARK PHASE	*Carbon assimilation* $CO_2 + 2TPNH_2 + n\ ATP \longrightarrow (CH_2O) + H_2O + 2TPN + n\ ADP + n\ P$	*Pyridine nucleotide reduction* $2PN + 2H_2 \longrightarrow 2PNH_2$ *Carbon assimilation* $CO_2 + 2PNH_2 + n\ ATP \longrightarrow (CH_2O) + H_2O + 2PN + n\ ADP + n\ P$
	Sum $CO_2 + 2H_2{}^{*}O \xrightarrow{\text{light}} (CH_2O) + {}^{*}O_2 + H_2O$	Sum $CO_2 + 2H_2 \xrightarrow{\text{light}} (CH_2O) + H_2O$

The non-cyclic electron transport process which, in photosynthesis of green plants, results in a light-dependent reduction of triphosphopyridine nucleotide, evolution of oxygen, and the formation of adenosine triphosphate is visualized as shown in Fig. 1. This process shares with cyclic photophosphorylation the primary photochemical reaction (equation 4) and the phosphorylating site (equation 7). It differs from the cyclic pathway in that the electron expelled in reaction 4 does not return to the chlorophyll molecule but is removed from the cyclic pathway by triphosphopyridine nucleotide, and used (along with the accompanying proton) either for the reduction of carbon dioxide and the formation of carbohydrates during normal photosynthesis, or, under special conditions, for the production and accumulation of reduced triphosphopyridine nucleotide (equation 2).

To keep the chlorophyll system functional the electrons removed by non-cyclic transport must be continuously replenished. It is suggested that this is accomplished by an interaction between hydroxyl ions (or water) and a cytochrome component peculiar to the photosynthetic apparatus of green plants but absent in photosynthetic bacteria. This reaction, represented by equation 14, is visualized as being possibly an 'anode'-type dark reaction, in which

OH^- ions yield molecular oxygen and donate electrons, via a cytochrome chain (equations 14, 11, 7), to chlorophyll, where they are raised, at the expense of absorbed light energy, to the reducing potential required in photosynthesis. The protons (equation 12) are donated to triphosphopyridine nucleotide as it is reduced (equation 13) and, in combination with electrons, provide the hydrogen atoms used in the formation of carbohydrates. A corollary of the scheme is that water, though not undergoing photolysis, is still the source of the oxygen evolved in photosynthesis by green plants.

The reactions leading to oxygen evolution appear to be thermodynamically feasible, since the energy contribution of one einstein of red light, about 43 kcal., is equivalent to a potential of 1·9 V. per faraday. This is more than sufficient to carry out the half reaction, $2H_2O \rightarrow O_2 + 4H^+ + 4e$, which at 25° and pH 7 has $E'_0 = 0{\cdot}815$ V. per faraday.

The sum of reactions 4*b*, 12, 13, 14, 11 and 7 would, as shown below, result in the non-cyclic type of photophosphorylation (equation 2).

$$2\,(\mathrm{Chlp} + h\nu) \longrightarrow 2\,(\mathrm{Chlp})^+ + 2\text{ electrons} \qquad (4b)$$

$$2\,H_2O \longrightarrow 2\,H^+ + 2\,OH^- \qquad (12)$$

$$\mathrm{TPN_{ox}} + 2\,H^+ + 2\text{ electrons} \xrightarrow{\text{reductase}} \mathrm{TPNH_2} \qquad (13)$$

$$2\,OH^- + 2\,\mathrm{Fe^{3+}cyt_{II}} \longrightarrow 2\,\mathrm{Fe^{2+}cyt_{II}} + 1/2\,O_2 + H_2O \qquad (14)$$

$$2\,\mathrm{Fe^{2+}cyt_{II}} + 2\,\mathrm{Fe^{3+}cyt_{I}} \xrightarrow{Cl^-} 2\,\mathrm{Fe^{3+}\,cyt_{II}} + 2\,\mathrm{Fe^{2+}cyt_{I}} \qquad (11)$$

$$2\ \mathrm{Fe^{2+}cyt_{I}} + (\mathrm{Chlp})^+ + \mathrm{ADP} + H_3PO_4 \rightarrow 2\,\mathrm{Fe^{3+}cyt_{I}} + 2\,\mathrm{Chlp} + \mathrm{ATP} \qquad (7)$$

$$\text{Sum: } \mathrm{TPN} + 2\,H_2O + \mathrm{ADP} + H_3PO_4 + 2\,h\nu \longrightarrow \mathrm{TPNH_2} + 1/2\,O_2 + \mathrm{ATP} + H_2O \qquad (2)$$

The non-cyclic photophosphorylation (equation 3) coupled with the reduction of ferricyanide (represented here by Fe^{3+}) is regarded as a variant of the triphosphopyridine scheme in which reaction 13 has been replaced by reaction 15.

$$2\,Fe^{3+} + 2\text{ electrons} \longrightarrow 2\,Fe^{2+} \qquad (15)$$

The sum of reactions 4*b*, 15, 12, 14, 11 and 7 would then result in the non-cyclic photophosphorylation represented by equation 3.

Ferricyanide was already used (Table 2) to demonstrate that, without chloride, chloroplasts behaved like chromatophores. Ferricyanide was also used in the presence of chloride (Table 2) to show that the non-cyclic electron transport system is absent in bacterial photosynthesis. When chloride was added to the reaction mixture the inhibition of cyclic photophosphorylation by ferricyanide was overcome in the case of chloroplasts but not of chromatophores. This would be expected if the chloroplasts were able to complete the non-cyclic electron transport system via reactions 14 and 11 resulting in oxygen evolution. Oxygen evolution would proceed until all the ferricyanide was reduced, at which time the inhibition of cyclic photophosphorylation would disappear. In the case of chromatophores the addition of chloride would not overcome the ferricyanide inhibition of cyclic photophosphorylation since the bacterial system cannot carry out the non-cyclic electron transport in which ferricyanide is reduced and oxygen is released.

Cytochromes in Photosynthetic Cells

The proposed hypothesis assigns an important role in the photosynthetic process to cytochromes. This is based on extensive research in other laboratories. Hill, Scarisbrick and Davenport[57-60] found that the hæmatin content of leaves is much higher than that of other plant tissue. They found that a new cytochrome component, *f*, was found only in green tissues, and, as shown by Davenport[58], was confined to chloroplasts. Hill[59] has also identified another cytochrome characteristic of chloroplasts, cytochrome b_6. Elsden, Kamen, Vernon and Newton[61-64] isolated characteristic cytochrome components, one of which resembles cytochrome *c*, from photosynthetic bacteria of both the facultative and the strictly anaerobic photoautotrophic type.

Another basic premise of the proposed theory is that the cytochromes active in the photosynthetic apparatus become predominantly oxidized on illumination (cf. equation 7). This is necessary for photosynthetic phosphorylation, but, in the case of green plants, also for oxygen evolution. It is the predominantly oxidized state of cytochromes which is considered to provide the requisite positive potential on which the evolution of oxygen from OH^- ions would depend. Evidence from several laboratories indicates that oxidation of cytochromes promptly follows the illumination of photosynthetic pigments. Lundegardh[65] found that on illumination of *Chlorella* cells, leaves or leaf homogenates, cytochrome *f* becomes predominantly oxidized. The oxidation of cytochrome components of algæ and photosynthetic bacteria following illumination, was reported by Duysens[66], Chance and Sager[67], Chance and Smith[68], Olson and Chance[69] and Smith and Ramirez[70]. Of interest in this connexion is also the report of Nieman and Vennesland[71] on the presence of a cytochrome photo-oxidase in chloroplasts.

It appears that despite variation in methods and experimental materials the evidence from different laboratories supports the principal conclusion that oxidation of cytochrome components follows illumination of photosynthetic cells. Although it is premature at this time to equate the cytochrome reactions postulated here with known cytochrome components or to assume that the complete photosynthetic cytochrome chain is already known, it seems likely that the cytochromes already found to be specific to chloroplasts and photosynthetic bacteria will prove to be involved in the postulated reactions or their equivalents.

Cyclic Photophosphorylation and Carbon Dioxide Assimilation in Green Plants

In developing the theme that cyclic photophosphorylation is a mechanism shared by all photosynthetic cells it was implied, but not proved, that in carbon dioxide assimilation, green plants, like photosynthetic bacteria, still depend on this mechanism for adenosine triphosphate formation although they have evolved the non-cyclic type (reaction 2) of photophosphorylation which is peculiar to them. Stated in other terms, it was implied that adenosine triphosphate formed by reaction 2 alone is insufficient for the assimilation of carbon dioxide to the level of carbohydrate.

Experimental evidence for the participation of cyclic photophosphorylation in carbon dioxide assimilation by chloroplasts had to be sought in a system different from the one described before[10]

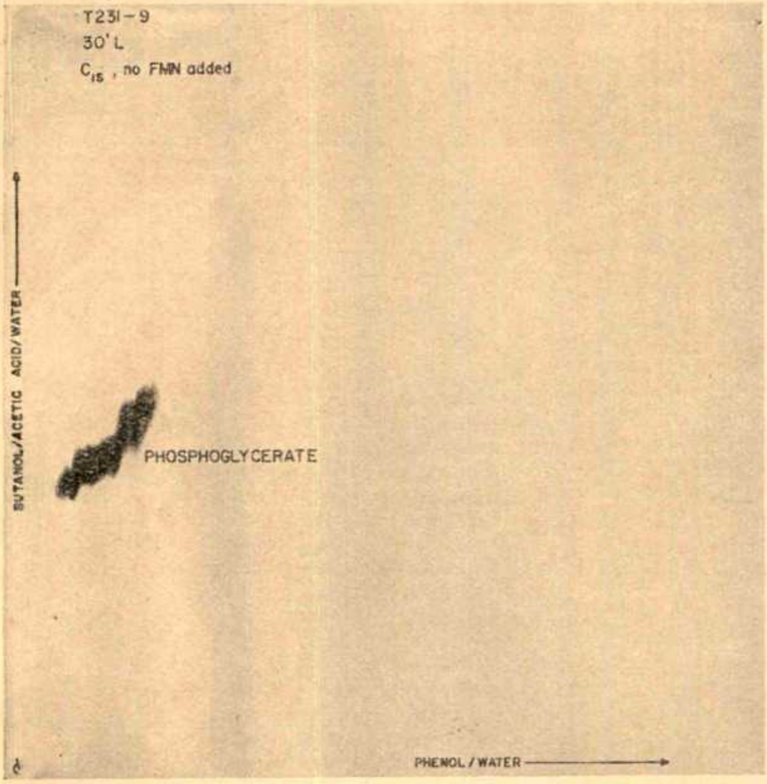

Fig. 2. Radio-autograph of a chromatogram showing products of photosynthetic $^{14}CO_2$ assimilation by illuminated chloroplasts in the absence of added riboflavin phosphate (cf. refs. 8, 24)

in which reduced triphosphopyridine nucleotide and adenosine triphosphate were first generated in substrate amounts by means of reaction 2, and then used later for the assimilation of carbon dioxide in the dark. Here reduced triphosphopyridine nucleotide and adenosine triphosphate were already supplied in excess and a second reaction for generating adenosine triphosphate would be superfluous. However, evidence for the participation of cyclic phosphorylation in carbon dioxide assimilation by isolated chloroplasts was recently obtained by Trebst *et al.*[8,24] in a catalytic system, that is, one in which, as in an intact cell, reduced triphosphopyridine nucleotide and adenosine triphosphate were present in *catalytic* amounts and carbon dioxide fixation was therefore possible only in the light while reduced triphosphopyridine nucleotide and adenosine triphosphate were being continuously regenerated at the expense of absorbed light energy.

Carbon dioxide assimilation in this catalytic system was investigated, under three conditions: (*a*) when the photochemical phase was limited to non-cyclic photophosphorylation reaction (reaction 2); (*b*) when the photochemical phase was limited to cyclic photophosphorylation (reaction 1); and (*c*) when the photochemical phase included both reactions 1 and 2.

Figs. 2 and 3 show that under conditions (*a*) and (*b*) carbon dioxide assimilation was limited almost entirely to the formation of phosphoglycerate. As shown in Fig. 4, the formation of sugar phosphates, which is taken as a measure of a reductive (photosynthetic) carbon dioxide assimilation in this reconstituted chloroplast system, was observed only in case (*c*) when a proper balance was established between the non-cyclic photophosphorylation reaction (equation 2) and cyclic photophosphorylation (equation 1).

In the experiments illustrated by Figs. 2, 3 and 4 the balance between the non-cyclic and cyclic photophosphorylation was maintained by adding different amounts of one of the catalysts of cyclic photophosphorylation, riboflavin phosphate, vitamin K or phenazine methosulphate. Concordant results were also obtained by Trebst *et al.*[8] with inhibitor experiments. For example, using the uncoupling effect of ammonia[55] on both cyclic and non-cyclic

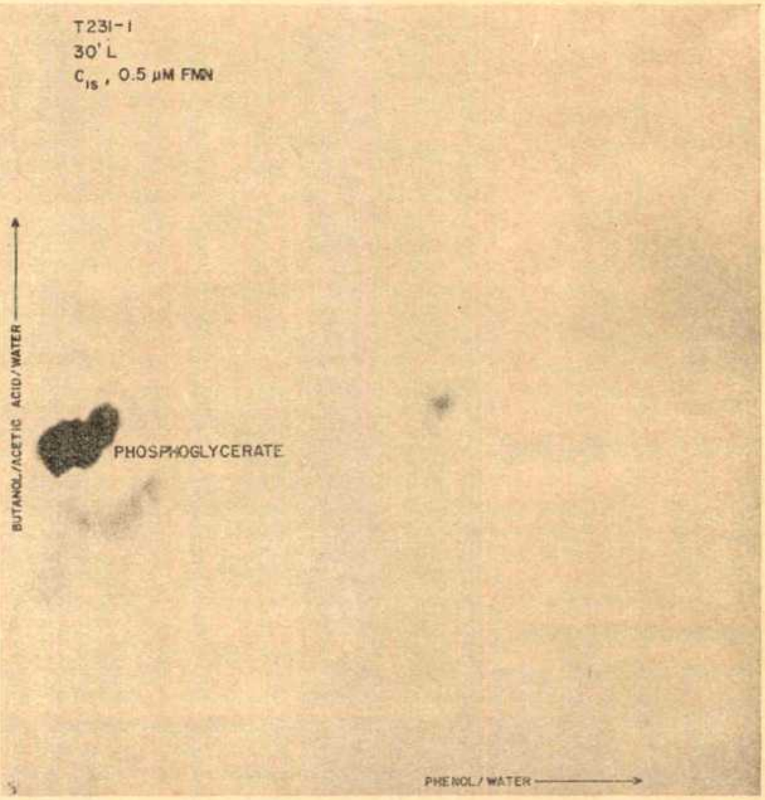

Fig. 3. Radio-autograph of a chromatogram showing products of photosynthetic $^{14}CO_2$ assimilation by illuminated chloroplasts supplied with 0·5 μmole riboflavin phosphate (cf. refs. 8, 24)

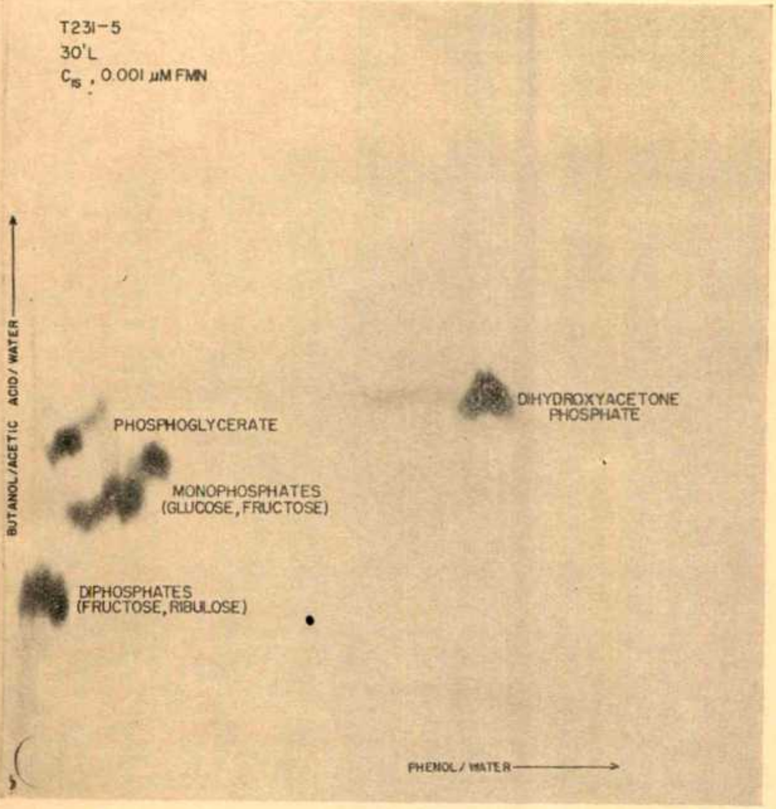

Fig. 4. Radio-autograph of a chromatogram showing products of photosynthetic $^{14}CO_2$ assimilation by illuminated chloroplasts supplied with 0·001 µmole riboflavin phosphate (cf. refs. 8, 24)

photophosphorylation it was possible to suppress the formation of adenosine triphosphate by illuminated chloroplasts (reactions 1 and 2) without inhibiting the reduction of triphosphopyridine nucleotide in reaction 2. Under these conditions, carbon dioxide fixation was completely abolished except when the "acceptor" substance for carbon dioxide was ribulose diphosphate. In that case a single product, phosphoglyceric acid, was formed by the carboxylase reaction (cf. review ref. 72), which does not depend on added adenosine triphosphate; but in the absence of adenosine triphosphate, the phosphoglyceric acid was not reduced by the reduced triphosphopyridine nucleotide.

Parallel experiments of Losada *et al.*[9] on specific enzyme systems in chloroplasts fortified these lines of evidence and supported the conclusion, that in a reconstituted "catalytic" chloroplast system (in which carbon dioxide assimilation can occur only in the light) non-cyclic photophosphorylation alone (reaction 2) does not provide sufficient adenosine triphosphate for a reductive assimilation of carbon dioxide to the level of carbohydrate. Additional adenosine triphosphate must be supplied by cyclic photophosphorylation (equation 2).

General Comments

Modified elements of the proposed hypothesis have been considered by other authors (cf. review ref. 21). The first comprehensive theoretical proposal for a role of adenosine triphosphate in photosynthesis, within the framework of the photolysis of water hypothesis was formulated by Ruben[73] in 1943. Shortly thereafter, Emerson, Stauffer and Umbreit[74] proposed that the "sole function of light energy in photosynthesis is the formation of 'energy-rich' phosphate bonds". They included in this generalization both green plants and photosynthetic bacteria, and made no provision for a photochemical generation of a reductant for carbon dioxide assimilation by green plants. But the main reason why their proposal has met with little acceptance in the ensuing years was the lack of substantial experimental evidence in their experiments with *Chlorella* (cf. refs. 75, 76) for participation of phosphorus in photosynthesis.

With respect to cytochromes, Davenport and Hill[60] suggested that the primary photochemical process in photosynthesis is the *reduction* of 4 molecules of oxidized cytochrome *f* by one quantum of light which transfers 4 electrons in a reaction resulting in a decomposition of water to give molecular oxygen. They envisaged, then, a dismutation type of reaction, in which half the reduced cytochrome is re-oxidized by oxygen to provide additional energy needed to produce another cytochrome with a more reducing potential. A series of such energy dismutations would, as they envisaged, finally result in the production of a reductant with a potential low enough for carbon dioxide assimilation.

Kamen[77] has suggested that "the splitting of water as such may not be involved in the initial light reaction but can occur instead as a result of the transfer and storage of energy during dark back-oxidations". He proposed that "single quantum events mediate the production of adenosine triphosphate and other high energy compounds" and that "the evolution of oxygen [occurs] as a result of the gradual accumulation of a store of oxidized material. In the case of bacteria, the oxidants are removed by reaction with exogenous H donors".

The hypothesis proposed here rules out the formulation of oxygen precursors in bacterial photosynthesis and assigns to the exogenous hydrogen donors the role of carbon dioxide reductants. But the reduction of carbon dioxide also requires adenosine triphosphate, and what distinguishes photosynthetic from non-photosynthetic bacteria is the ability to form adenosine triphosphate at the expense of light energy by cyclic photophosphorylation. In the case of facultative photoautotrophs, such as the purple bacteria, "light and oxygen are interchangeable"[5]. This is now interpreted as meaning that these organisms use the same carbon dioxide reductants in light and in dark, but have two ways for forming adenosine triphosphate: either anaerobically in the light or aerobically in the dark.

The capacity to transform light energy absorbed by chlorophyll into pyrophosphate bond energy, rather than the photochemical formation of a carbon dioxide reductant, is regarded as the common denominator of photosynthetic metabolism in bacteria and in green plants. Reasons were given elsewhere[4] for considering cyclic photophosphorylation, in the time scale of biochemical evolution, as a "primitive" type of photosynthesis which preceded that now found in green plants.

Viewed in this light, green plants appear to have acquired an "open", non-cyclic type of electron transport for reducing triphosphopyridine nucleotide by a photochemical reaction (equation 2) while retaining cyclic photophosphorylation common to green plants and photosynthetic bacteria. This departure from the "primitive" photosynthetic pattern was made possible by the evolution of suitable enzymes such as the light-dependent triphosphopyridine nucleotide reductase[45,56], and a chloride-dependent cytochrome system, one member of which is assumed to be capable of evolving oxygen from water. With regard to the role of chloride in photosynthetic reactions, it is of interest that Arisz[78] and Van Lookeren Campagne[79] have found a light-dependent chloride absorption in *Vallisneria* leaves.

The main features of the proposed hypothesis explain and reconcile the observed photochemical reactions in green plants and photosynthetic bacteria as they are now known ; but it is expected that other aspects of the hypothesis will be modified and amplified as new facts become known. Despite the basic similarity between cyclic photophosphorylation in green plants and photosynthetic bacteria it is possible that the detailed mechanism of this process may be different in the highly aerobic cellular environment of green plants from that in the strictly anaerobic environment of photosynthetic bacteria. The uncertainty as to the role of ascorbate (cf. ref. 26, 80) is another aspect which must await further clarification. It is also now difficult to explain satisfactorily why, in view of the large concentration of vitamin K in chloroplasts (cf. reviews, refs. 24, 26), additions of catalytic amounts of this substance would still be necessary for cyclic photophosphorylation, unless it is assumed that endogenous vitamin K performs another function in chloroplasts[82], conceivably, by acting in the chloride-dependent electron transport chain. On the other hand, the effect of phenazine methosulphate is consistent with the postulated participation of cytochromes in this process. Singer and Kearney[81] have shown that succinic dehydrogenase as well as "other cytochrome reducing dehydrogenases" react faster with phenazine than with any other known hydrogen acceptor.

Different aspects of photosynthesis received recognition in successive periods of its history. To its discoverers, Priestley and Ingen-Housz, photosynthesis seemed at first a cosmic device for correcting bad air by generating oxygen (dephlogisticated air). For a long period afterwards research in photosynthesis was dominated by the conviction, later shown to be erroneous, that carbon dioxide assimilation was peculiar to photosynthesis. Finally, photolysis of water, as manifested by evolution of oxygen by green plants, came to be regarded as the basic photochemical reaction in photosynthesis. Now it appears that the main feat of photosynthesis, the conversion of light into chemical energy, is, fundamentally, even in green plants, more closely linked with phosphorus than with carbon assimilation. In green plants but not in photosynthetic bacteria this energy-conversion process, geared to phosphorus metabolism, is accompanied by the formation of a carbon dioxide reductant and oxygen evolution.

This investigation was aided by grants from the National Institutes of Health and the Office of Naval Research.

[1] Arnon, D. I., Allen, M. B., and Whatley, F. R., *Nature*, **174**, 394 (1954).
[2] Arnon, D. I., Whatley, F. R., and Allen, M. B., *J. Amer. Chem. Soc.*, **76**, 6324 (1954).
[3] Arnon, D. I., paper presented at the Cell Symposium, Amer. Assoc. Adv. Sci., Berkeley Meeting, 1954 ; *Science*, **122**, 9 (1955).
[4] Arnon, D. I., Whatley, F. R., and Allen, M. B., *Science*, **127**, 1026 (1958).
[5] Van Niel, C. B., in "Photosynthesis in Plants", edit. J. Franck and W. E. Loomis, 437 (Iowa State College Press, 1949).
[6] Bové, J., Whatley, F. R., and Arnon, D. I. (manuscript in preparation 1959).
[7] Ogata, S., Nozaki, M., and Arnon, D. I. (manuscript in preparation, 1959).
[8] Trebst, A. V., Losada, M., and Arnon, D. I. (manuscript in preparation, 1959).
[9] Losada, M., Trebst, A. V., and Arnon, D. I. (manuscript in preparation, 1959).
[10] Trebst, A. V., Tsujimoto, H. Y., and Arnon, D. I., *Nature*, **182**, 351 (1958).
[11] Thimann, K. V., *Science*, **88**, 506 (1938).
[12] Trudinger, P. A., *Biochem. J.*, **64**, 274 (1956).
[13] Aubert, J. P., Milhaud, G., and Millet, J., *Ann. Inst. Pasteur*, **92**, 515 (1957).
[14] Calvin, M., Proc. Third Intern. Congr. Biochem. Brussels, 1955, 211 (Academic Press, New York, 1956).
[15] Racker, E., *Nature*, **175**, 249 (1955).
[16] Racker, E. (personal communication, 1958).
[17] Gaffron, H., Fager, E. W., and Rosenberg, J. L., *Symposia Soc. Exp. Biol.*, **5**, 262 (1951).
[18] Calvin, M., and Benson, A. A., *Science*, **107**, 476 (1948).
[19] Calvin, M., Bassham, J. A., Benson, A. A., Lynch, V. H., Ouellet, C., Schou, L., Stepka, W., and Tolbert, N. E., *Symposia Soc. Exp. Biol.*, **5**, 284 (1951).
[20] Bassham, J. A., Benson, A. A., Kay, L. D., Harris, A. Z., Wilson, A. T., and Calvin, M., *J. Amer. Chem. Soc.*, **76**, 1760 (1954).
[21] Arnon, D. I., "Ann. Rev. Plant Physiol.", **7**, 325 (1956).
[22] Avron, M., Krogmann, D. W., and Jagendorf, A. T., *Biochim. Biophys. Acta*, **30**, 144 (1958).
[23] Vishniac, W., and Ochoa, S., *J. Biol. Chem.*, **198**, 501 (1952).
[24] Arnon, D. I., Brookhaven Symposia in Biology, No. 11, 181 (1958).
[25] Arnon, D. I., Whatley, F. R., and Allen, M. B., *Biochim. Biophys. Acta*, **32**, 47 (1959).
[26] Whatley, F. R., Allen, M. B., and Arnon, D. I., *Biochim. Biophys. Acta*, **32**, 32 (1959).
[27] Krebs, H. A., and Kornberg, H. L., *Ergeb. Physiol.*, **49**, 212 (1957).
[28] Frenkel, A. W., *J. Amer. Chem. Soc.*, **76**, 5568 (1954).
[29] Frenkel, A. W., *J. Biol. Chem.*, **222**, 823 (1956).
[30] Geller, D. M., doctoral dissertation, Div. Med. Sci., Harvard Univ. (1957).
[31] Geller, D. M., and Gregory, J. D., *Fed. Proc.*, **15**, 260 (1956).
[32] Mattick, J. L., and Lindstrom, E. S., paper presented before Mid-west Section of Amer. Soc. Plant Physiol., Ann Arbor, Mich. (June 1957).
[33] Williams, A. M., *Biochim. Biophys. Acta*, **19**, 570 (1956).
[34] Kamen, M., and Newton, J. W., *Biochim. Biophys. Acta*, **25**, 462 (1947).
[35] Anderson, E. C., and Fuller, R. C., *Arch. Biochem. Biophys.*, **76**, 168 (1958).
[36] Schachman, H. K., Pardee, A. B., and Stanier, R. Y., *Arch. Biochem. Biophys.*, **38**, 245 (1952).
[37] Thomas, J. B., *Koninkl. Ned. Akad. Wetenschap. Proc.*, Ser. C., **55**, 207 (1952).
[38] Whatley, F. R., Allen, M. B., and Arnon, D. I., *Biochim. Biophys. Acta*, **16**, 605 (1955).
[39] Krall, A. R., Avron, M., and Jagendorf, A. T., *Biochim. Biophys. Acta*, **26**, 431 (1957).
[40] Arnon, D. I., Allen, M. B., and Whatley, F. R., *Biochim. Biophys. Acta*, **20**, 449 (1956).
[41] Arnon, D. I., Whatley, F. R., and Allen, M. B., *Biochim. Biophys. Acta*, **16**, 607 (1955).
[42] Wessels, J. S. C., *Rec. Trav. Chim. des Pays-Bas*, **73**, 529 (1954).
[43] Whatley, F. R., Allen, M. B., and Arnon, D. I., *Plant. Physiol.*, **32** (Supp.), iii (1957).
[44] Wessels, J. S. C., *Biochim. Biophys. Acta*, **25**, 97 (1957).
[45] Arnon, D. I., Whatley, F. R., and Allen, M. B., *Nature*, **180**, 182 (1957).
[46] Jagendorf, A. T., and Avron, M., *J. Biol. Chem.*, **231**, 277 (1958).
[47] Warburg, O., "Heavy Metal Prosthetic Groups and Enzyme Action", 213 (Oxford, 1949).
[48] Arnon, D. I., and Whatley, F. R., *Science*, **110**, 554 (1949).
[49] Broyer, T. C., Carlton, A. B., Johnson, C. M., and Stout, P. R., *Plant Physiol.*, **29**, 526 (1954).
[50] Martin, G., and Lavollay, J., *Experientia*, **14**, 333 (1958).
[51] Lewis, G. N., and Lipkin, D., *J. Amer. Chem. Soc.*, **64**, 2801 (1942).

[52] Lehninger, A L , Wadkins, C L , Cooper, C , Devlin, T M , and Gamble, J L , *Science*, **128**, 450 (1958)
[53] Harrison, K , *Nature*, **181**, 1131 (1958)
[54] Clark, V M , Kirby, G W , and Todd, A , *Nature*, **181**, 1650 (1958)
[55] Jagendorf, A T , Brookhaven Symp in Biology, No 11, 236 (1958)
[56] San Pietro, A , and Lang, H M , *J Biol Chem* , **231**, 211 (1958)
[57] Hill, R , and Scarisbrick, R , *New Phytol* , **50**, 98 (1951)
[58] Davenport, H E , *Nature*, **170**, 1112 (1952)
[59] Hill, R , *Nature*, **174**, 501 (1954)
[60] Davenport, H E , and Hill, R , *Proc Roy Soc* , B, **139**, 327 (1952)
[61] Elsden, S R , Kamen, M D , and Vernon, L P , *J Amer Chem Soc* , **75**, 6347 (1953)
[62] Vernon, L P , and Kamen, M D , *J Biol Chem* , **211**, 643 (1954)
[63] Newton, J W , and Kamen, M D , *Arch Biochem Biophys* , **58**, 246 (1955)
[64] Newton, J W , and Kamen, M D , *Biochim Biophys Acta*, **21**, 71 (1956)
[65] Lundegardh, H , *Physiologia Plantarum*, **7**, 375 (1954)
[66] Duysens, L N M , *Nature*, 173, 692 (1954), *Science*, **120**, 353 (1954), **121**, 210 (1955)
[67] Chance, B , and Sager, R , *Plant Physiol* , **32**, 548 (1957)
[68] Chance, B , and Smith, L , *Nature*, **175**, 803 (1955)
[69] Olson, J , and Chance, B , *Biochim Biophys Acta*, **28**, 227 (1958)
[70] Smith, L , and Ramirez, J , *Arch Biochem Biophys* , **79**, 233 (1959)
[71] Nieman R H , and Vennesland, B , *Science*, **125**, 353 (1957)
[72] Vishniac, W , Horecker, B L , and Ochoa, S , *Adv Enzym* , **19**, 1 (1957)
[73] Ruben, S J , *J Amer Chem Soc* , **65**, 279 (1943)
[74] Emerson, R L , Stauffer, J F , and Umbreit, W W , *Amer J Botany*, **31**, 107 (1944)
[75] Rabinowitch, E I , “Photosynthesis and Related Processes”, **1**, 228 (Interscience Publishers, New York, 1945)
[76] Whittingham, C P , *Biol Rev* , **30**, 40 (1955)
[77] Kamen, M D , ‘Enzymes Units of Biological Structure and Function”, edit O H Gaebler (Academic Press, New York, 1956)
[78] Arisz, W H , *Proc Kon Ned Akad Wetensch* , C, **50**, 1019 (1947)
[79] Van Lookeren Campagne, R N , *Acta Botan Neerl* , **6**, 543 (1957)
[80] Marrè, E , and Arrigoni, O , *Biochim Biophys Acta*, **30**, 453 (1958)
[81] Singer, T P , and Kearney, E B , *Biochim Biophys Acta*, **15**, 151 (1954)
[82] Bishop, N I , *Proc U S Nat Acad Sci* , **44**, 501 (1958)

OBITUARIES

Sir William Larke, K B E

SIR WILLIAM JAMES LARKE, who died on April 29, three days after his eighty-fourth birthday, deserves honourable remembrance among scientists for his powerful advocacy of scientific research in the service of industry Born in 1875, educated at Colfe's School, and trained as an engineer with H F Joel and Co , Finsbury, and Siemens Brothers at Woolwich, Larke was engineer and manager of the British Thomson-Houston Company's power and mining department from 1899 until 1912, when he became executive engineer During the First World War he served with the Ministry of Munitions and was appointed director-general of raw materials in 1919

In 1922 Larke accepted an invitation to become director of the National Federation of Iron and Steel Manufacturers and it was here that he found his first experience of organizing co-operative research for an entire industry The result was the establishment of the Iron and Steel Industrial Research Council, of which Sir William was the chairman from 1938 until 1945, and ultimately of the British Iron and Steel Research Association, which now carries on the work

Sir Charles Goodeve, director of the British Iron and Steel Research Association, writes "BISRA is now the largest of the research associations and it may not be generally appreciated that its predecessor operated on a small scale with a headquarters staff of about fifteen acting as the technical department of the British Iron and Steel Federation Under the guidance of Larke and the head of the British Iron and Steel Federation Technical Department, the late Mr E C Evans, a substantial and effective research programme was carried out with a very modest budget, and few can have excelled Larke and Evans in their ability to stretch available funds to the utmost They had no laboratories of their own and much of the programme was carried out by works personnel or in academic institutions under the general direction of committees serviced by the small central staff But this staff also did practical work themselves, and the goodwill built up by Larke in steel companies and in university laboratories meant that facilities were readily provided Between 1924 and 1939 studies of the performance of blast furnaces, open hearth furnaces and rolling mills were carried out and several of the fundamental principles governing efficiency were determined Many of the methods used were basically similar to those which are now known as operational research"

Sir William was sixty when, in 1935, the international symposium on welding organized by the Iron and Steel Institute convinced him of the importance of the new processes for the joining of metals and of the need for an effective programme of fundamental research in this field He was then a member of the advisory council to the Committee of the Privy Council for Scientific and Industrial Research, and with characteristic energy set himself to reorganize the Institution of Welding Engineers and to secure for it the support of such eminent engineers as the late Sir Alexander Gibb, and from the Department of Scientific and Industrial Research and industry the financial backing necessary for a co-operative research organization in welding From the Institute of Welding's Welding Research Council, of which Larke was chairman from its formation in 1936, came research results of great value in the war-effort of 1939–46, and out of it the present British Welding Research Association was formed in 1946

A leader of scientific research rather than a scientist, Larke inspired both affection and respect in those who worked with him, and the impress of his critical and constructive mind remains in many institutions in the field of engineering and metallurgy He was exceptional in his readiness to welcome new ideas late in life, retaining to the end a lively and informed interest in the institutions to which he had given so much, where a generation now in sight of retirement remembers the kindly wisdom of his advice and the high standards of efficiency and service which he set them as their goal

GUY PARSLOE

Prof. William Moffitt

ON December 19, 1958, William Moffitt, associate professor of chemistry in Harvard University, died suddenly of a heart attack at the age of thirty-three in Cambridge, Massachusetts Thus ended a brilliant career which already had a great impact on his chosen field of theoretical chemistry and seemed destined to go on to even higher levels of achievement

Moffitt was born on November 9, 1925, in Berlin His father, a British citizen, was in Germany on a government mission Moffitt's early schooling was by private tutoring, but at the age of eleven he became

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a pupil at the Harrow County Boys' School. He proceeded to a first-class honours degree in chemistry at New College, Oxford (1946). Two years of research at Oxford led to a D.Phil. in 1948 and a position with the British Rubber Producers' Research Association at Welwyn, where he enjoyed great freedom to follow his chosen lines of inquiry. In 1953, he went to the United States to become assistant professor of chemistry at Harvard. Only two years later, he was appointed associate professor, one of the youngest to receive this rank.

In 1956, he married Dorothy Silberman of Cambridge, Massachusetts; their daughter Alison was born in July 1958.

Moffitt's papers all deal with the application of quantum mechanics to the problem of the electronic energies of molecules and related optical properties. His earlier publications were prepared at Oxford, where he studied under Prof. C. A. Coulson, with whom he collaborated in a number of applications of molecular orbital theory. A noteworthy product of this collaboration was the introduction of the idea of 'bent bonds'; that is, chemical bonds formed from overlapping atomic orbitals not directed along the line joining the two bonded atoms.

After leaving Oxford, Moffitt continued to publish applications of current methods but was struck with their inadequate quantitative accuracy. He was thereby led to make perhaps his best-known contribution, that of the method of 'atoms in molecules'. He reasoned that one of the causes of the poor results then being obtained in calculations of chemical binding energies was that these rather small energies came out as the difference of two huge energies—the total electronic energies of the molecule and of its separated atoms. Consequently, he worked out a procedure by which the interaction between the atoms was treated as a perturbation and its effects separated from the internal energies of the atoms themselves. The latter were obtained from accurate spectroscopic data on free atoms.

At Harvard, he continued his interest in the theoretical elucidation of the ultra-violet spectra of large conjugated molecules. One contribution was a refinement of the free-electron perimeter model, particularly elegant because of the simplicity of its starting point and the number of experimental observations which it correlates. It has been stated that his work in the spectra of aromatic molecules is comparable in this field "to the importance of the complete theory of the Zeeman effect in interpreting atomic spectra".

In addition to his earlier interests, Moffitt characteristically took full advantage of his new scientific environment. Thus, part of the reason for his entry into the field of optical activity was provided by his interest in the research going on in the Harvard Laboratories concerning helical macromolecules and sterols. A major effort was begun which continued to the time of his death and which, though unfinished, helped to provide structural chemistry with a new tool. Moffitt's theoretical analysis of the problem of the optical activity of helical polypeptides, metal co-ordination compounds, and large ketones guided him to an appreciation of the importance of the circular dichroism and the properties of the absorption bands which are responsible for the optical activity. He demonstrated that such bands could be characterized by parameters, extractable from the rotatory dispersion data, which are sensitive to the nature of the asymmetrical environment of the chromophoric group involved in the transition. It is this structural sensitivity which promises to be so useful to the organic chemist.

This work was a fitting and logical application of the knowledge, skills and experience which Moffitt had acquired earlier. He was thoroughly conversant with the techniques of the theoretical physicist, accomplished in the application of advanced mathematical methods, and at the same time learned in a remarkably wide range of chemistry.

Another area in which he was continuing was the interaction of electronic and nuclear motions, especially in the John-Teller effect. This has to do with the instability of nuclear configurations which would lead to degenerate electronic energy-levels.

Few men had as great an impact at so early an age. The reasons are clear. Few have been endowed with such a sparkling, quick and keen intelligence, with such a capacity for spending long hours in the thorough study of fundamental subjects, with such high standards; and finally, but by no means least, with such a warm, outgoing, and appealing personality. Moffitt had tremendous innate assets and he used them fully and efficiently. His intellectual powers were not only applied to the solution of problems but perhaps even more to their wise selection. He avoided areas where only formal solutions were attainable, with no contact with experience.

Moffitt's quickness of mind was obvious to all, as was his interest and devotion to science. Perhaps not so obvious was the effort he expended, both in self-improvement and in the execution of his ideas. His scientific papers were prepared with great care. Each one went through draft after draft until he had finally hand-written a version that met his exacting standards. The use of refined and proper language was for him a necessity, obviously based on his enjoyment and wide knowledge of English literature. His lectures, both in courses and on special occasions, were prepared with the same care as his manuscripts. They were well-organized, clear, elegantly phrased and beautifully delivered.

Moffitt was much more than a scientist of outstanding distinction; he was a cultivated man in the broadest sense, an enthusiastic athlete, and a human being of rare warmth, friendliness and consideration. His death not only deprives science of a great mind but also takes away for ever from his numerous friends and associates a great spirit.

E. Bright Wilson, jun.

Dr. Gustav J. Kramer

On April 19, Dr. Gustav Kramer, *Abteilungsleiter* at the Max-Planck-Institut fur Verhaltensphysiologie and *Leiter* at the Vogelwarte Radolfzell of the Max-Planck-Gesellschaft zur Forderung der Wissenschaften, fell to his death while endeavouring to collect wild fledgling pigeons during a scientific expedition to Calabria in southern Italy. With his death in his fiftieth year there must be a halt to very promising researches upon the homing, migration and orientation of birds and other animals and upon a multiplicity of allied problems. But such has been the inspiration which he has offered to his students and assistants that we may hope that his ideas will for many years yet continue fertilizing this field of study.

Gustav Kramer was born in Mannheim on March 11, 1910, and came of a wine-growing family. After studying at the Universities of Freiburg, Konigsberg and Berlin, he joined the staff of the Kaiser-Wilhelm-Institut fur medizinische Forschung, working upon the sensory physiology of *Xenopus* and upon the metabolic processes of poikilotherms. In 1934 he was appointed assistant at the joint German–Italian Marine Biological Laboratory at Rovigno d'Istria, and three years later assistant director of the Physiological Department of the Stazione Zoologica at Naples. Here it was that he married an Italian zoologist. During this period he continued his work on the metabolism of poikilotherms, concentrating upon cœlenterates and lizards. From this arose an investigation into the island and mainland races of lizards, with biometrical, genetical and hybridization findings.

It was not until after the Second World War, when he spent two years as lecturer in Heidelberg, that Dr Kramer's life-long interest in birds led him into the field where his name will best be remembered, that of bird orientation, and when, in 1948, he was appointed as a departmental director at the Max-Planck-Institut at Wilhelmshaven he was able to devote most of his energies to investigating this problem. The decade since this appointment has seen the publication of a remarkable series of papers in which he has established the dependence of birds on the Sun and upon an 'internal chronometer' for their feats of orientation, homing and migration. In 1958 the Max-Planck-Gesellschaft recognized Dr Kramer's achievements and promise by appointing him to direct an institute of animal behaviour, which was to be built at a site of his choosing. It is still under construction at Walddorf (Tubingen). Less than three weeks before his death, the Gesellschaft made him director of its Radolfzell bird observatory (formerly the well-known Rossitten bird observatory).

Gustav Kramer was an athlete and climber of some note, and it is ironic that he should have met his death while using his climbing ability in his scientific work. He is survived by his widow and by three children. His unfailing charm and hospitality and the inspiration he gave to his students, staff and scientific acquaintances will be remembered with affection.

D B Carlisle

NEWS and VIEWS

Dr Warren Weaver

On August 1, Dr Warren Weaver retired from his present position as vice-president for the natural and medical sciences of the Rockefeller Foundation. He has been appointed vice-president of the Alfred P Sloan Foundation, and he will continue his activities on the National Science Board, on the National Advisory Cancer Council, on the Council for Library Resources, as vice-chairman of the Health Research Council of the City of New York, and as vice-president and chairman of the Committee on Scientific Policy of the Sloan-Kettering Institute for Cancer Research. For twenty-seven and a half years Dr Weaver has had, within the Rockefeller Foundation, administrative responsibility for all activities in the natural sciences. When the Rockefeller Foundation became active in agriculture in the early 1940's this field was placed under Dr Weaver's general charge. Still more recently, in 1955, he was also assigned supervisory responsibility for the Foundation's activities in the medical sciences.

Astronomy at Glasgow

Prof W M. Smart

Prof W M Smart, regius professor of astronomy in the University of Glasgow since 1937, is to retire on September 30. Prior to 1937 Prof Smart had a background which combined Cambridge mathematics and theoretical astronomy with naval navigation practice and teaching. During this period he was engaged in research in stellar dynamics, particularly with the phenomena of star streaming and stellar motion. His development of a flourishing school of theoretical astronomy in Glasgow was based on this experience. To assist in his teaching work, and to help theoretical astronomy everywhere, he wrote three well-known and widely used astronomical text-books in addition to a number of other books of academic, educational and popular interest. He encouraged his department in studies in stellar motion and other theoretical problems. It is understood he will move to the London area on retirement.

Prof. P A. Sweet

Dr P A Sweet has been appointed to succeed Prof Smart. He has, since 1952, been a lecturer in astronomy at University College, London, and also assistant director of the University of London Observatory. The incoming professor is not new to Glasgow, having lectured there during 1947–52. After completing the Mathematical Tripos at Cambridge in 1946, Dr Sweet commenced theoretical researches in the field of stellar structure and plasma physics. His theory concerning the rate of mixing of the material in stars has had wide consequences in the analysis of stellar structure and evolution. His more recent work has been connected with the influence of magnetic conditions on the control of energy reactions in cosmic material. The applications of his theories to stellar and other problems are still in progress. We may anticipate a development of these and other studies with Dr Sweet's appointment to the regius professorship in astronomy at Glasgow.

Jacob Bell . Founder of the Pharmaceutical Society of Great Britain

On June 12, the hundredth anniversary of his death, tribute was paid by the Pharmaceutical Society of Great Britain to its founder, Jacob Bell, when the president, Mr Gwilym Hughes, unveiled a tablet to Bell's memory in Woodbury Park Cemetery, Tunbridge Wells, where he is buried. By his work for the Society, said Mr Hughes, Jacob Bell was acting in the public interest as well as in the interests of his calling. When he commenced his labours, pharmacy in Great Britain was ill-defined, unregulated and unorganized, without acknowledged standards of education or practice. It had no authoritative means of expression and lacked official recognition.

When Bell died, substantial progress had been made in overcoming these difficulties and the practice of pharmacy had been set upon a path of development which subsequent events had shown to be sound In the evening Mr Hughes gave a review of Jacob Bell's life and work at the Society's House in Bloomsbury Square, where a commemorative exhibition was held during the following week

Charles Cagniard de la Tour (1777–1859)

CHARLES CAGNIARD DE LA TOUR (or Cagniard-Latour), who died one hundred years ago on July 5, 1859, was a distinguished engineer and physicist, who also made original contributions to chemistry and to medicine Born in Paris on March 31, 1777, he attended the Ecole militaire de Rebais and the Ecole polytechnique and qualified as *ingénieur-géographe* In 1811 he was appointed to the Ministry of the Interior, and eight years later was created baron for supplying the Hôpital St Louis and the Usine Royale with gas-lighting He was elected to the Paris Academy of Sciences in 1851 His name is specifically attached to two inventions—a blowing machine and a siren The former, the *cagniardelle,* is an Archimedean screw, immersed obliquely in a tank of water and rotated in a direction opposite to that required for raising water The siren, for determining the number of vibrations corresponding to a sound of any particular pitch, was extensively used for signalling on ships Cagniard de la Tour also experimented on the mechanism of voice production ("Considérations et expériences diverses sur la voix humaine", 1837) In 1822–23 he studied the effects of heat and pressure on liquids and determined for each liquid a definite temperature (later called the critical temperature), above which it did not remain liquid in spite of the highest attainable increase of pressure These investigations were continued and extended by Faraday With Theodor Schwann in Germany he originated the germ theory in 1837 by his discovery that yeast consists of a mass of globules which are vegetable in nature and that it is responsible for fermentation ("Mémoires sur la fermentation vineuse") This theory was promptly abandoned two years later when Liebig insisted that the process was purely chemical, but was resurrected by Pasteur in 1856

British Space Research

IN reply to a question in the House of Lords on July 29, Lord Hailsham said that in their recent visit to the United States to discuss co-operation in the field of scientific research in space using earth satellites, Prof Massey and his small team of experts had had most valuable and fruitful discussions with the National Aeronautics and Space Administration As a result it is proposed the British scientists will prepare instruments for satellites to be placed in orbit by the use of the *Scent* vehicle which the National Aeronautics and Space Administration is developing for use in connexion with civil scientific research Several vehicles might be involved over three to four years These proposals have been approved by the Government subject to the conclusion of formal arrangements Information regarding these programmes and their results will be made available to the international scientific community Both the British and the American groups regard this project as a valuable development in scientific co-operation Meanwhile, the arrangements for design studies of British launches, announced by the Prime Minister, are unaffected

Canadian Committee on Space Research

THE National Research Council of Canada has formed an Associate Committee on Space Research jointly with the Defence Research Board The new Committee will have co-ordination duties and will advise on international co-operation Scientific subjects to be studied will include geomagnetism, the aurora, meteorology, cosmic rays, radiation from the Sun, and chemical composition of the upper atmosphere This Canadian work, now in hand, may be enhanced by series of high-altitude rockets carrying measuring instruments The new Committee will be particularly useful to Canadian university groups interested in research in the upper atmosphere They will have an opportunity to design their own experiments, and to build instruments for the nose cones of rockets The rocket range at Churchill will probably be used Canadian and American groups have already been co-operating in maintaining this range The new Committee includes members from a number of Government departments and agencies, and from universities with research teams in related fields The secretary of the Committee is Mr B D Leddy, National Research Council, Ottawa 2

The *Dragon* Project

THE first meeting of the International Board of Management of the high-temperature reactor project of the Organization for European Economic Co-operation (*Dragon*) was held recently at the Atomic Energy Establishment, Winfrith, Dorset, where the reactor experiment is to be built Dr Sigvard Eklund, of Sweden, was elected chairman of the Board for the current year, with Sir John Cockcroft, of the United Kingdom, as vice-chairman Sir John was succeeded in this office by Sir William Penney on July 1 The Board appointed Mr C A Rennie, of the Atomic Energy Research Establishment, Harwell, as chief executive of the project The Board, which includes representatives of the signatories of the *Dragon* Agreement, namely, Austria, Denmark, Belgium, France, Germany, Italy, Luxembourg, The Netherlands, Norway, Sweden, Switzerland and the United Kingdom, considered and approved a broad programme of work and a budget for the financial year, 1959–60, on the basis of preparatory work by a General Purposes Committee under the chairmanship of Dr J Gueron (Euratom)

The Scripps Institution of Oceanography

THE Scripps Institution of Oceanography has announced its intention to send two ships on an ambitious oceanographic and geophysical investigation of the western Pacific Ocean and eastern Indian Ocean to last six months between February and August 1960 Particular attention will be paid to studies of the sea floor, and to areas such as the Java trench, where previous work has posed specific problems The programme will include dredging, coring, measurements of heat flow, seismic, magnetic and gravity surveys, studies of the interchange of carbon dioxide between sea and air, and sampling for radioisotopes and trace elements The biological programme will consist of plankton sampling and mid-water trawling as well as dredging The memorandum received from the Director of the Scripps Institution says that visiting scientists and suggestions as to subjects for examination will be welcomed

Agricultural Aviation Group

An Agricultural Aviation Group has recently been formed by the Royal Aeronautical Society The aims of the Group are to further the use of aircraft in agriculture, forestry, pest control, fertilizing, seeding, chemical application and similar subjects and to provide facilities for those interested in such matters to meet and exchange ideas and information The formation of the Agricultural Aviation Group was largely inspired by Mr S W G Foster, an Associate Fellow of the Society and a design consultant The Group expects to take an active part in the International Agricultural Aviation Conference which is to be held at Cranfield in September The Agricultural Aviation Group is the second group to be formed within the Society since the Council agreed to the formation of groups to cover small specialized fields of aeronautics An indication of the wide range of the interests of members of the Society is given by the fact that the Society now has an Astronautics and Guided Flight Section, a Man-Powered Aircraft Group, an Agricultural Aviation Group, and, within the next month or two, will also have a Historical Group

Efficient Use of Man-power in Industry

The report of an inquiry undertaken by the National Joint Advisory Council into practices impeding the full and efficient use of man-power has now been published by the Ministry of Labour and National Service (pp 16 London H M Stationery Office, 1959 1*s* net) The inquiry was concerned with restrictive labour practices, and the Council considers that the results of the inquiry are encouraging Some 64 industries reported that they had no problems in regard to the efficient use of man-power and a further 42 had set up machinery to deal with any such problems or appeared to be establishing such machinery Six industries needed more time, or because of various difficulties had been unable to make a joint examination, though some of these industries are of considerable importance in the national economy, and the Council expresses concern about the position in this group In the ship-building and ship-repairing industry there are problems which need to be tackled if greater efficiency is to be achieved and this calls for efforts from both employers and trades unions More generally, the report points out that much depends on the use to which joint machinery is put, but the existence of an organization for joint consultation and the fact that such organization functions will afford some grounds for both hope and confidence

Tyneside Association of Libraries for Industry and Commerce

The Tyneside Association of Libraries for Industry and Commerce was formed last September under the sponsorship of the Northern Regional Board for Industry, the Tyneside Productivity Committee, and the North East Industrial and Development Association Having its headquarters at the Commercial and Technical Department of the Central Library, New Bridge Street, Newcastle upon Tyne 1, the main purpose of the Association is the co-ordination and development of existing facilities in the Tyneside area in order "to help industry and commerce by making information readily and quickly available" Use of the service is available to any one free of charge, membership is open to any firm or organization which maintains a library and/or information department, and is willing to supply non-confidential information on request To reduce the burden on headquarters, the brochure describing the service suggests that inquiries should, in the first place, be directed to the nearest public library, if that fails (or if the matter is urgent) the inquiry may be sent direct to the Association's headquarters The chairman of the Association is R A Cookson, vice-chairman of the Northern Regional Board for Industry The honorary secretary is the Newcastle City Librarian, from whom copies of the brochure may be obtained

Chemical Control of Eelworms on Strawberries

The effectiveness of chemical substances in the control of the several eelworms which infest strawberries has been examined and discussed by R S Pitcher (*J Hort Sci*, 34, No 2, 1959) Although the hot-water treatment gives a satisfactory control of eelworm, it has several disadvantages, notably that it is time-consuming, exacting, and requires precision, and it cannot be used in the field on an already established and growing crop Hence the desirability of discovering chemical methods of control In the present investigation, a number of nematicides were tested under pot conditions and field trials were carried out with parathion All treatments rapidly reduced the symptoms caused by the three eelworm species, but the persistence of the remedial effect varied according to the kind of infestation involved Pre-planting dips were consistently more effective than spraying of established plants in the field With each of the three eelworm species, the level of infestation was greatly reduced by parathion (0 1 per cent of active ingredient), whether used as a drench, spray, or pre-planting dip

Non-Cartridge Type Demineralized Water Units

Water demineralizing, or de-ionizing, units are now superseding the still and distilled water delivered in carboys as a source of supply of purified water for laboratories and similar establishments A feature of many such units, however, is their reliance on detachable cartridges of ion exchange resins which are returned to the supplier when exhausted The Mark 4 and Mark 5 Portable "Deminrolit" plants manufactured by the Permutit Co, Ltd, Gunnersbury Avenue, London, W 4, have been designed for easy 'on the spot' regeneration of the exhausted ion exchange material, thus obviating the need for detachable cartridges and replacements Both plants consist of a pair of sealed columns charged respectively with "Zeo-Karb" cation and "De-Acidite" anion exchange resins, the water being passed through the columns in that order Flexible connexion and delivery tubes, with a multi-valve control system, facilitate operation and regeneration A built-in dial-type conductivity tester enables 'spot' checks to be made on the quality of water being produced By this means the point at which regeneration becomes due may be determined precisely Regeneration involves flushing the cation column with a dilute solution of hydrochloric acid and the anion column with dilute caustic soda or soda ash solution Both columns are then rinsed with water, when the plant is ready for further use Both plants are constructed throughout from non-corrodible materials and operate at normal cold water tap temperatures and pressures

Rutherford Memorial Appointments

UNDER the terms of the scheme to commemorate the late Lord Rutherford of Nelson the following appointments have been made by the Council of the Royal Society Sir Lawrence Bragg has been appointed Rutherford Memorial Lecturer for 1960, to deliver the lecture in New Zealand Mr D J Tritton, now working at the Cavendish Laboratory, Cambridge, has been appointed Rutherford Scholar for 1959 for three years, to investigate the relationship between the manner of production of turbulence in a fluid flow and the large eddy structure of that turbulence, at the department of aeronautical engineering, Indian Institute of Science, Bangalore

Canadian National Research Council Scholarships for 1959–60

THE National Research Council of Canada has granted 399 scholarships for 1959–60, with a total value of 844,600 dollars Three hundred and forty-one of these scholarships are for graduate work at Canadian universities Awards for study abroad include thirty-three special scholarships, to be held in the following countries eighteen in the United Kingdom , fourteen in the United States , and one in France Twenty-five postdoctorate overseas fellowships have been granted for work in the following countries nineteen in the United Kingdom , five in France , and one in the Netherlands

University News

California

A DEPARTMENT of Virology has been established in the University of California at Berkeley Chairman of the new Department is Dr Wendell M Stanley, Nobel laureate and director of the Virus Laboratory Eight faculty members, drawn from the Virus Laboratory, now comprise the staff of the Department Starting in September 1959, lecture courses will be offered to graduate and advanced undergraduate students, to be followed later by a comprehensive laboratory course Additional instruction will be offered, mostly at graduate level, in the form of special study courses, seminars, and research projects

Ibadan

PROF F W SANSOME, professor of botany in University College, Ibadan, Nigeria, has been appointed professor of botany in the University College of Ghana, Achimota He is to be succeeded at Ibadan by Dr E Njoku, at present senior lecturer in the College

London

THE new Sir John Atkins Laboratories, of which Sir John Atkins laid the foundation stone on June 24, will enable important and urgently needed developments to take place at Queen Elizabeth College, London The College is the only institution in Britain that provides courses leading to a degree in nutrition (B Sc Nutrition, London) and shares with the University of Bristol the distinction of preparing students for the only degrees in household science (B Sc Household Science, London) In the new buildings, which will house the Departments of Bacteriology, Biology and Nutrition, more students can be accommodated and much more research in these subjects can be undertaken More accommodation for teaching and research will also be available for the five other science departments which will expand in the present buildings

Michigan

DR WRAY SMITH has been appointed assistant director of the Willow Run Laboratories He will continue to be responsible to the director and associate director of the Willow Run Laboratories for the direction of the administrative staffs of the laboratories and for assisting the director and associate director in formulating and implementing administrative policies and procedures He has been on the Willow Run Laboratories staff since 1954 and has been administrative associate since early in 1958

Prof Louis J Cutrona, professor of electrical engineering in the University of Michigan, has been appointed head of the largest of the several laboratories within Willow Run The Radar Laboratory is involved in major programmes in the field of airborne and ground-based radars with support through Project Michigan, the U S Air Force and the Advanced Research Projects Agency

Announcements

AT the first commencement on June 18, the honorary degree of D Sc was conferred on Dr Peyton Rous and on Dr Herbert S Gasser for their contributions to the development of the Institute and the attainment of its high standards in research and scholarship

SIR HUGH BEAVER was recently elected president of the Royal Statistical Society for the ensuing year Mr B Benjamin, Miss J I Douglas and Dr P Armitage were re-elected honorary secretaries, and Mr R F Fowler was re-elected honorary treasurer

DR F KENNETH BRASTED, former president of the University of Dallas, has joined Texas Instruments Incorporated as administrative director of its Central Research Laboratory

DR MARGARET HANNAH has been awarded the Warner Medal which is given by the Textile Institute for outstanding work in textile science and technology Dr Hannah was formerly a lecturer in textile engineering in the University of Leeds

THE ninth Annual Instrument Symposium and Research Equipment Exhibit will be held during September 28–October 1 at the National Institutes of Health, Bethesda, Maryland Further information can be obtained from James B Davis at the above address

THE third conference on Analytical Chemistry in Nuclear Reaction Technology will be held in Gatlinburg, Tennessee, during October 26–28 Further information can be obtained from C D Susano, Oak Ridge National Laboratory, P O Box Y, Oak Ridge, Tennessee

ERRATUM In the "News and Views" item entitled "Ultrasonic Vibrations at 10,000 Megacycles", published in *Nature* of June 6, p 1570, the work referred to is being carried out by Dr E H Jacobsen, a member of the General Electric Company Research Laboratory, Schenectady, New York, and not by Dr E H Jackson, as printed

MORE LAND-USE PLANNING

WHATEVER posterity may remember of the term of office of the thirty-third President of the United States, Harry S Truman, it is unlikely ever to forget those trenchant sentences of his inaugural address of January 20, 1949, "Fourth, we must embark on a bold new programme for making the benefits of our scientific advances and industrial progress available for the improvement and growth of the under-developed areas For the first time in history, humanity possesses the knowledge and the skill to relieve the suffering of these people" As the programmes then initiated and the other innumerable activities directed towards helping the less developed countries have progressed, it has become increasingly apparent that the knowledge possessed by humanity is far from adequate In no sphere is this more true than in the proper use and management of land in the tropics—whether the humid tropics or the arid The lesson is still being learnt, after a number of major failures, that the secret is to make haste slowly and to build upon a firm foundation of factual knowledge Reference has been made in a recent issue of *Nature* (183, 20 , 1959) to the large-scale land-use maps of the Gambia and Singapore being prepared as a basis for planning, and it is clear that many other countries are working along comparable lines

Among the many research projects undertaken by the Institut National pour l'Étude agronomique du Congo belge (INEAC) is one for a soil and vegetation survey The results are being published as a series of fully coloured small sheets, one of soils and another of vegetation, with an explanatory memoir To date a dozen *livraisons* have been published, or are in the press, but a simple calculation suggests that about 7,000 sheets will be required to cover the whole territory on the scale of 1 50,000 which has been chosen Taking as an example[*] Planchette 3 (Lilanda) of the Yangambi area (Livraison 6) prepared by three soil scientists and a botanist, sixteen soil series and three complexes are distinguished The soils are classified by parent material and by class of drainage—"chaque unité reconnue en fonction de ces deux facteurs reçoit le rang de série" The complexity of the soil picture is accentuated in the vegetation map Small blank areas mark cultivated fields, but even at the scale of 1 50,000 the major vegetation types cannot be shown without recourse to stripes for "mélanges" and small circles in a background for "mosaiques" Such is the true measure of the complex natural environment within which development is to take place

On the western side of the Atlantic a Soils Research and Survey Section under the direction of T A Jones has been set up at the Regional Research Centre of the British Caribbean at the Imperial College of Tropical Agriculture, Trinidad The first three monographs to be published cover the parish of St Catherine, Jamaica, the Rupununi savannahs of British Guiana, and the island of St Vincent[*] The first two have soil maps on a scale of 1 50,000—the first with pink symbols on a black outline, the second in black only, while the St Vincent map comprises three sheets on the scale of 1 20,000 The soils are grouped in St Vincent according to parent material (soils over recent alluvium, old alluvium, limestone, granodiorite, etc) whereas in British Guiana there is a tentative local classification based on geomorphological regions (well-drained soils of the pediments, imperfectly drained soils of elevated flats, etc) The Jamaica monograph combines the two In the explanatory memoirs there are elaborate tabular statements giving the important characteristics of each soil, recommended cultivation practices and crops for each There are detailed descriptions of the soil profiles and a new scheme of 'land capability classes' is introduced In place of the familiar eight classes of the American system, seven are recognized, each divided into *e* (erosion danger), *w* (excess water), *s* (shallow or droughty) and so on In contrast to the Belgian work this is a far more subjective approach it suggests an over-emphasis on soil and perhaps a passing over of lessons to be learnt from existing vegetation and land use In due course it will be most enlightening to know how far the practical recommendations have been followed and the results

Unesco is much concerned with the problems of both the arid and humid tropics Arising out of the Kandy Symposium[†] held in 1956, a vegetation map of the whole of Malaysia (including all New Guinea) has been compiled by C G G J van Steenis and published with the collaboration of Unesco[‡] At a scale of 1 5,000,000 it is highly generalized and approaches the problem of land-use in the humid tropics from a very different point of view—that of the broad overall perspective It has been possible, however, to show a dozen types of forest as well as the main areas of 'savannah', grass, alpine grass, wet rice, dry fields and plantations, making eighteen categories in all

The need for a stock-taking of land resources and of the present use of land is by no means confined to the tropics Wherever there is a heavy pressure of population on land it forces itself upon the attention of governments and research organizations In Italy the Consiglio Nazionale delle Ricerche has undertaken the preparation of a comprehensive Carta della Utilizzazione del Suolo, now being published on the scale of 1 200,000 in 23 sheets[§] The work is under the capable direction of Prof Carmelo Colamonico, who writes an introduction to the first two descriptive memoirs The first is on Calabria (sheets 19 and 20) by Ferdinando Milone , the second, on Sicily (sheets 21, 22 and 23) by the same author. A preliminary sheet of central Italy was shown to the Congress of the International Geographical Union at Washington in 1952 and the maps, in full colour, show twenty categories of land-use following closely the recommended categories laid down by the Commission on the World Land Use Survey. The Survey has since recognized the vital importance of separating irrigated and non-irrigated lands, which has been done on the Italian maps. Anyone familiar with Mediterranean lands will know the intimate mixtures of trees and ground crops—olives with cereals, for example—and will recognize the justification of this mixed category. Little of Sicily is shown as 'sterile' except the higher slopes of Etna.

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[*] Publications de l'Institut National pour l'Étude Agronomique du Congo Belge Carte des Sols et de la Vegetation du Congo Belge et du Ruanda-Urundi 6 Yangambi Planchette 3 Lilanda A Sols B Vegetation Notice explicative de la Carte des Sols et de Vegetation par P Gilson, P Jongen, A Van Wambeke et L Liben Pp 36+2 cartes (Bruxelles Institut National pour l'Étude Agronomique du Congo Belge, 1957)

[*] The Regional Research Centre of the British Caribbean at the Imperial College of Tropical Agriculture, Trinidad Soil and Land-use Surveys No 1 Jamaica—Parish of St Catherine By K C Vernon Pp 42 20*s* No 2 British Guiana—The Rupununi Savannas By R F Loxton, G K Rutherford and J Spector Pp 33 15*s* No 3 St Vincent By J P Watson, J Spector and T A Jones Pp 70 25*s* (Trinidad Imperial College of Tropical Agriculture, 1958)

[†] Proc. Kandy Symposium, Unesco, 1956, pp 68–73 (1958)

[‡] Unesco, Paris published for the Unesco Humid Tropics Research Project (1958)

[§] Consiglio Nazionale delle Ricerche, Napoli Corso Vittorio Emanuele, 165 (1958–59)

Though differing widely in their methods and execution, all these maps illustrate the growing recognition that before land can be planned the present position must be surveyed and analysed.

L. DUDLEY STAMP

AGRICULTURAL RESEARCH IN EIRE

AN FORAS TALÚNTAIS (THE AGRICULTURAL INSTITUTE)

AN Foras Talúntais was established under the Agriculture (An Foras Talúntais) Act, 1958, and commenced activities on August 1, 1958. Its functions include reviewing, facilitating, encouraging, assisting, co-ordinating, promoting and undertaking agricultural research in the Republic of Ireland. The Institute has authority to provide, where necessary, new facilities and staff to carry out research, to assist in carrying out specific research projects and to make grants for the extension and development of facilities to scientists actively engaged in agricultural research. The Institute is specifically obliged to disseminate the results of agricultural research, particularly to those engaged in agricultural advisory work. As one of its major and general functions the Institute has a statutory obligation to advise the Minister for Agriculture on any matter relating to agricultural research or agricultural science on which advice is requested by him. As part of its educational activity in the promotion and encouragement of agricultural research, the Institute may provide and organize courses of study in agricultural research and related subjects, and it may also provide and organize seminars, conferences, lectures and demonstrations on agricultural research; it may grant scholarships, and award fellowships to persons who have done outstanding work in relation to agricultural science or agricultural research.

The Institute is an autonomous national body, governed by a Council which consists of a chairman and twelve ordinary members. The chairman is appointed by the President of Ireland. Five members of the Council are nominated by agricultural and rural organizations; the nomination is by means of election by a panel of twenty-five organizations divided into five groups; one member is nominated by each of the governing bodies of the University Colleges of Cork, Dublin and Galway and the Board of Trinity College, Dublin, and the three remaining members are nominated by the Government of the Republic of Ireland. The activities and staff of the Institute are under the control of a director responsible to the Council as chief officer of the Institute. The finances of the Institute are provided for under a number of headings. From the Counterpart Special Account, by arrangement between the United States and the Irish Governments, the Institute has available a capital fund of £840,000 to be expended on capital projects and an endowment fund of £1,000,000. A grant towards the expenses of the Institute will be paid every financial year out of monies provided by the Irish Government. The Institute is empowered to accept gifts of money, land or other property under specified conditions which must be consistent with the functions of the Institute. With regard to gifts and fees for specific research projects, the Institute looks for support particularly to industries and businesses closely associated with agriculture and to farming organizations and individuals interested in agricultural development.

The activities of the Institute have been organized on the basis of a headquarters consisting of a secretariat, scientific and agricultural liaison offices and statistical library and information services, together with five main Research Divisions as follows: (1) Soils, (2) Plant Sciences and Crop Husbandry, (3) Animal Production, (4) Rural Economy and (5) Horticulture and Forestry. The scientific liaison office will make and maintain contact with agricultural research and allied services in other countries, while in addition providing for the scientific development and co-ordination of the research programme at home. The agricultural liaison office will ensure the closest possible contact, co-operation and integration of effort between the Institute, departments of State, the advisory services and the farming community. A specialist advisory service in each facet of agriculture will be provided for advisory officers and others.

The work of the different Divisions is being developed on the following general basis. The Soils Division will carry out research and specialist advisory activities in the spheres of soil physics, soil chemistry and biochemistry, soil microbiology, soil fertility and fertilizer use, plant nutrition and physiology, soil classification and survey, land reclamation and land use and the manuring, ecology and survey of grassland. A national soil-survey has already commenced. The Plant Sciences and Crop Husbandry Division will be chiefly concerned with improving the yield and quality of a wide variety of agricultural crops, and will accordingly cater for research in plant breeding, plant pathology, crop protection, entomology, plant introduction (including crops for commercial and other special purposes), plant composition, weed control and general aspects of crop husbandry. The Animal Production Division will cover all phases of animal production from grassland management and feeding to product quality. The work will be organized in the following departments: grassland management, animal husbandry, animal nutrition and biochemistry, physiology, breeding and genetics and meat research. The headquarters of this Division will be at the National Research Centre for Animal Production, at Grange, Dunsany, Co. Meath. A research centre for dairying is being established at

Moore Park, Fermoy, Co Cork, and a sheep research centre at Creagh, Ballinrobe, Co Mayo The Rural Economy Division will include departments of farm management, agricultural economics, agricultural marketing, rural sociology, home economics and agricultural engineering It will provide a service for the economic evaluation of the research in other divisions and for the general management programme of the Institute's farms An agricultural machinery testing service is being organized The horticultural work of the Horticulture and Forestry Division will be carried out at centres dealing with glasshouse and vegetable crops, soft fruits, pomology and bee-keeping A National Research Centre for Glasshouse and Vegetable Crops has been established at Kinsealy, Malahide, Co Dublin In addition, a field experimental station to cater for soft fruits has been set up at Clonroche, Wexford, and an experimental unit for pomology research at Dungarvan, Co Waterford

The foundation ceremony of An Foras Talúntais, commencing with religious services, was held in Dublin on May 19 The opening of the headquarters' offices of An Foras Talúntais at 33 Merrion Road, Ballsbridge, Dublin, by the President of Ireland, and the unveiling of a commemorative plaque acknowledging Unites States aid in the foundation of the Institute, took place in the afternoon

The following officers of the Institute have been appointed

Director Dr. T Walsh

Dr T Walsh graduated in 1937 and was awarded a postgraduate scholarship which he held in the Soil Science Department, University College, Dublin He took the degrees of M Agr Sc in 1938, Ph D in 1940 and D Sc in 1946 on published work He was elected a member of the Royal Irish Academy in 1954 During 1938–45 he was assistant lecturer in soil science, in University College, Dublin, and during 1945–52, soils advisory officer in the Department of Agriculture He was senior inspector in charge of soils and grassland research during 1952–58 In August 1958 he was appointed director of the Agricultural Institute He has represented the Republic of Ireland at many scientific and agricultural conferences and is national representative on a number of committees of the Organization for European Economic Co-operation and the United Nations Food and Agriculture Organization He was responsible for building up research facilities in soils and grassland research in the Department of Agriculture, especially at Johnstown Castle Agricultural College Dr Walsh has specialized in pedology, soil fertility, plant nutrition, and more recently in grassland husbandry with particular reference to the soil fertility – animal nutrition aspects of this subject, and has published some seventy scientific papers

Chief of the Animal Production Division Dr L. B. O'Moore

Dr Laurence Butler O'Moore, who has been appointed chief of the Animal Production Division, took the degrees of M R C V S at the Veterinary College in 1945, M Sc at the University of Dublin for a thesis on the "Physiology of Reproduction" in 1946, and Ph D at the University in 1950 for a study on "Phosphorus Deficiency in Grazing Cattle" Since 1948 he has been on the staff of the Veterinary Research Laboratory, Department of Agriculture, where he held the post of superintending senior research officer with responsibility for research dealing with biochemistry, vaccine production and calf diseases Dr O'Moore is a well-known authority in the fields of animal biochemistry, physiology and nutrition His work on nutritional deficiencies and metabolic disturbances in animals at pasture is especially well known, his reputation in this particular sphere being world-wide

Chief of the Rural Economy Division . Mr J J Byrne

Mr James J Byrne, who has been appointed chief of the Rural Economy Division, was educated at St Kieran's College, Kilkenny, and the National University, and graduated in law, politics and economics in 1940, being awarded a postgraduate scholarship He took the M A (Economics) degree at the National University in 1941, being awarded a travelling studentship with which he proceeded to the University of Cambridge, where he was awarded the M Sc (Economics) degree in 1944, taking the LL B (National University of Ireland) in the same year In 1946, Mr Bryne became lecturer in economics in the University of Dublin, where he was appointed registrar of the Schools of Agriculture and Veterinary Medicine in 1955, and secretary of the Management Committee of the Kells Ingram Farm in 1957 During 1948–54, in addition to his duties in the University of Dublin, he was secretary of the Population Commission, and this work brought him into particularly close touch with the main national social problems Mr Byrne takes up his new post with an international reputation in the sphere of research in economics

BRITISH MAMMALS AND SOME OTHERS

An appreciable number of important papers were produced on a variety of subjects during the conference of the Mammal Society of the British Isles, which was held at Bristol during April 6–9 Miss J Shillito (University of Exeter) described her findings on the population structure, ecology and breeding of the common shrew (*Sorex araneus*) under wild conditions her observations showed much movement of juveniles before their breeding territories were established, the range covered by the males being rather greater than that by the females The various invertebrates consumed by shrews were also examined and listed The other insectivore investigated was the water shrew (*Neomys fodiens bicolor*) P A Jewell and A E Hawkins (Royal Veterinary College) had shown that the normal diet of this shrew had an exceedingly low calorific value, so that the great physical activity employed in the search for food was associated with a resting metabolic rate at least as low as that of a mouse fed on the same standard diet The Earl of Cranbrook pointed out that the saliva of this shrew was probably toxic, since worms bitten by the animal appeared to be paralysed

The food of the water vole (*Arvicola amphibius*), dormouse (*Muscardinus avellanarius*) and harvest mouse (*Micromys minutus*) was discussed by M Knight and their individual preferences noted Small mammals had been studied in the wild in two localities R M Newsom (Bureau of Animal Population) at Wytham had followed the population fluctuations in the bank vole (*Clethrionomys glareolus*), field vole (*Microtus agrestis*) and wood mouse (*Apodemus sylvaticus*) over some sixteen months The results of trapping and marking showed that although breeding of all three species ceased normally during the winter of 1957–58, they all continued to breed in the woodland during the winter of 1958–59 Work on the small mammals of South Rona was carried out by W O Copland and M J Delany (University of Southampton), who trapped for six days during August 1958 Small mammals proved very scarce, and only wood mice (*Apodemus sylvaticus*) and the common and pigmy shrews (*Sorex araneus* and *S minutus*) were found M J Delany had further compared the specific characters in *Apodemus sylvaticus* from the Scottish mainland with large series from Mull and Lewis, and found that these island races only differed from the mainland one in size he therefore concluded that there was no justification for considering *Apodemus hebridensis* as a distinct species With S Krishnaswamy and K A Munday (University of Southampton), he has used filter-paper electrophoresis on blood serum from various murids, and this method has shown that the pattern from the island race of *Apodemus* differs from that of *A sylvaticus* but is closely akin to that of *A flavicollis*

Among larger mammals, J E C Flux (University of Aberdeen) had investigated the colour change in wild specimens of the mountain hare (*Lepus timidus scoticus*) in Aberdeenshire The order in which moulting occurred in different parts of the body was noted and it was found that the spring moult took place much less abruptly than the autumn one G F Moysey showed an electrical device using a spring switch which he had used to obtain automatic records of badgers moving in and out of their setts, preliminary results gave fluctuations in the period of nocturnal activity near and far from the sett, which might be correlated with seasonal changes in badger behaviour

Roe deer (*Capreolus capreolus*) were touched upon by two members D Stephen made observations extending the calving season He also commented upon the absence of the stage of production of buttons by two young bucks kept by him, as a preliminary to the formation of the first antler spikes F J Taylor Page discussed the activity of mature bucks in fraying young trees as a territorial demarcation With T J Pickvance (University of Birmingham), he also described methods of carrying out region mammal surveys, with particular reference to those being carried out at present in the midlands and in Norfolk

The problem of erosion outside Britain was dealt with by H V Thompson, who spoke on the rabbit (*Oryctolagus cuniculus*) in Australia and New Zealand, while O Hook and H N Southern (Bureau of Animal Population) spoke of similar problems caused by the very large number of hippopotami in Uganda Control methods are being used against both these species Other foreign species came under review when Prof K Zimmermann (Berlin) spoke about rodents which he had collected in China, and which in some cases had been brought back alive to Berlin H Bohlken (Kiel) gave an account of his findings on the stomachs of the tylopoda and showed that there were important differences between those of tylopods and ruminants, this suggested that the faculty of rumination differs between these two groups and has been acquired twice over in the phylogenetic history of the artiodactyla

J F D Frazer

STRUCTURAL EFFECTS OF KINETIC HEATING

On April 21 an all-day discussion on "The Structural Effects of Kinetic Heating" was held by the Royal Aeronautical Society at the Institution of Mechanical Engineers

The chair was taken by Mr M B Morgan (deputy director, Royal Aircraft Establishment, Farnborough) In his opening remarks, he said that although the effects of kinetic heating had been pioneered by engine manufacturers, it was a comparatively new field for the structural designer of to-day In the future, kinetic heating effects would have to be taken into account in the design of very high-speed aircraft and missiles, so that the designer would have to become familiar with the scientific background to the problem

The first paper, "Some Factors affecting the Choice of Materials", was read by Mr W G Heath (A V Roe and Co, Ltd) He opened with the assumption that certain fundamental parameters were outside the control of the structures designer The designer must study the effect of these factors on suitable materials, considering not only structural efficiency, stiffness, creep, fatigue and thermal stress but also the availability of the materials and the ability of the workshops to handle them He showed curves giving a comparison of some of the materials available at the present time—aluminium alloys, titanium alloys and steels—which are suitable for structures operating at temperatures up to 500° C Later, brief mention was made of materials suitable for use at higher temperatures He urged every designer to throw away the curves, which he felt sure they all had, of specific strength plotted against temperature, as compression structure efficiency could not be determined from them, and they could be misleading even for tension structures Mr Heath showed curves of 'specific stability' parameters which he had derived He felt that these would be helpful in the choice of the most efficient material for short-life compression structures He stressed the need for more information concerning the effects of creep, fatigue and thermal stress on long-life structures, and the difficulty in obtaining satisfactory experimental results—a point in favour of 'fail-safe' design

He concluded that the final choice of material was strongly linked to the type of structure, and that availability and the workshop processes involved must be considered

During the discussion on this paper a plea was made for some convenient form of presentation of the necessary material properties data for design use, the stiffness and proof stresses in tension and compression would have to be given for each material at a given temperature over varying lengths of time For some of the new materials, which would have to be used for temperatures above 500° C, it was remarkably difficult to discover some of their properties and they were extremely difficult to work with Ultimately, it was the workshops that governed the choice of such materials

A plea was also made for much more compression creep testing to be carried out, which Mr Heath endorsed, saying that he thought the right proportion would be 60 per cent compression and 40 per cent tension testing

Asked for guidance on factors affecting material selection, Mr Heath said that many more materials data were required and suggested that the research activities of universities, technical colleges, etc, in Britain should be co-ordinated

From a structural point of view an opinion was voiced that the general heating problem could be simplified by trying to stop the thermal stresses from arising This could be done by cooling, insulation or other ways of smoothing out the thermal gradients

Dr J S Przemieniecki (Bristol Aircraft, Ltd) presented the next paper, on "The Design of Transparencies" He opened by considering briefly methods of calculating temperature distribution in transparent panels subjected to kinetic heating or cooling, and this led to discussion of the effects of non-uniform temperature distribution, differential expansion and the edge restraint preventing thermal deformations Methods of calculating thermal stresses were suggested, including the concept of 'self-equilibrating' temperature distribution, attention being concentrated on deriving simple engineering formulæ rather than on rigorous mathematical solutions

The choice of design cases for combined pressure and thermal loading was considered and it was shown that, in general, deceleration manœuvres combined with outward pressure constituted the design criteria The effects of various parameters on the magnitude of thermal stresses were analysed and it was shown that for a given material and panel geometry thermal stresses depended mainly on total temperature change, acceleration and the Biot number based on panel thickness Practical design aspects such as choice of material, strength, panel geometry and mounting were also considered Finally, testing of transparencies under pressure and thermal loading was briefly discussed, together with possible methods of strain measurement

During the discussion following this paper it was pointed out that transparencies have two somewhat unfortunate properties they have a very high resistance to heat flow, thus inducing high-temperature gradients and high outer surface temperature, and the radiation effect is small Some reduction of the outer surface temperature and temperature gradients could be effected by the use of double panels with cooling air between them, but it would not be practicable to cool externally the outer surface of the outer panel

Surprise was expressed at Dr Przemieniecki's assumption of zero heat transfer into the cabin It was stated that in fighters a large proportion of the heat entered the cockpit through the transparencies On the suggested method of cooling the inter-space between two panels it was thought to be difficult to get sufficient cooling potential in such a small space Dr Przemieniecki replied that although the assumption of zero heat transfer on the inside surface was an unrealistic case, it could be used effectively for design purposes

Another speaker remarked that the choice of materials for transparencies seemed to be very limited, but he felt that although fused silica had definite merits, toughened soda-lime glass might still be considered favourably for use in civil airliners, where the temperature changes would not be rapid, and where temperatures were not so high that the glass lost its toughening It was suggested to Dr Przemieniecki that the use of transparencies in supersonic aircraft was very limited and that retractable shutters could be a solution Dr Przemieniecki agreed, but thought that the engineering might be too difficult He would prefer to have no windows at all in the passenger cabin and to use closed-circuit television to overcome passenger objections to such a move Shutters could be used perhaps on special-purpose windows

The third paper, "Some Practical Aspects of Kinetic Heating Calculations", was read by Mr C L Bore (Hawker Aircraft, Ltd) He considered some of the practical difficulties encountered when estimating kinetic heating effects for an aeroplane, as distinct from an idealized structure Some of these difficulties arise in the estimation of heat transfer through the boundary layer They may be due to the variations of Mach number and altitude or to the differences between the behaviour of real air and an ideal gas Other difficulties arise from the interacting modes of heat transfer in the interior of a practical structure

He noted that transient temperatures can be found only by means of numerical methods, which have to be very adaptable and not too laborious He outlined methods which have been found suitable for this type of problem and gave some typical results

Interest was expressed in the parameters chosen for presenting the aerodynamic data, but Mr Bore was requested not to ask the aerodynamicists to produce charts showing the values of these parameters over a range of Mach numbers

The final lecture, on "The Advantages and Limitations of the Use of Models", was given by Mr A J Sobey (Royal Aircraft Establishment, Farnborough) He began his discussion on the prospective use of models by distinguishing between the small-scale work-piece used for extensive experiment in order to advance theory, and the replica used in a single representative test to verify design For a structural test evaluation under a realistic thermal field the design of a suitable model was shown to be subject to a series of constraints imposed on the designer by the consistent scaling of essential physical properties

It was shown that scaling of thermal conduction imposed two constraints and internal radiation a third The remaining degree of freedom in choice of scales vanished when the random variation of material properties with temperature forced an identity of temperature scales

The important role of the internal heat transfer process was exemplified in a design study in which some of the relevant parameters were varied and broad conclusions for practical structures were suggested

In the discussion one speaker could not accept the academic idea of infinite accelerations used in the study , but it was agreed that it had a valid application It was thought that Mr Sobey had given a rather depressing picture of the use of models for determining the thermal effects Mr Sobey agreed that models could not be devised to give full representation, but the small-scale work-piece was a useful instrument of scientific research

In bringing the discussion to a close, the chairman remarked on the vital importance of understanding test technique in order to keep ahead of actual aeroplanes, and also noted that there were already numerous aeronautical devices flying successfully while suffering from quite severe kinetic heating effects He concluded by saying that much was known about kinetic heating, but more knowledge was needed in order to refine designs for extreme efficiency

THE MATHEMATICAL ASSOCIATION

THE annual general meeting and conference of the Mathematical Association was held at Southampton during April 8–11 Most meetings were held at the University of Southampton, although the programme included also a civic reception in the Guildhall, visits to a computation laboratory, to a tidal model of Southampton Water and to places of interest in the district

The presidential address, delivered by Prof M H A Newman, was entitled "What is Mathematics ? New Answers to an Old Question" Prof Newman thought it desirable to consider the meaning of mathematics and that the present is a particularly suitable time for such a review There has rarely been a time when the work of mathematicians has been so strongly influenced and directed by their views on the nature of the subject From the revival of mathematics in the sixteenth century until well into the nineteenth century, mathematicians, though they took an interest in logical criticisms of the foundations, did not allow themselves to be deflected by any such criticisms from doing what they pleased

Then, in the latter half of the nineteenth century, there began a more penetrating analysis of the foundations of mathematics than there had ever been before

Soon after the beginning of this century two new and strongly opposed views of the nature of mathematics began to be heard, views which agreed only in their rejection of the interpretation of the logical analysts The 'intuitionist' views of Brouwer had a profound influence on our views about foundations, but had little effect on the direction taken by contemporary mathematics itself The views of Hilbert, on the other hand, have in fifty years led to a transformation of the whole aspect of mathematics Prof Newman said that the introduction of highly organized axiomatic structures has brought extraordinarily rich rewards, in the shape of massive advances, for example, in algebraic geometry of any number of dimensions and in differential geometry, which were entirely beyond the reach of the mathematical methods of even twenty-five years ago

Following these reviews and a consideration of mathematical analysis, Prof Newman asked what bearing these developments have on the problem of showing pupils at school the true nature of mathematics He said that the underlying principle of axiomatic mathematics, namely, that methods of doing things are what most interest mathematicians, or that methods are the heart of mathematics, can have a direct influence on teaching It implies that the meaning and interest of mathematics is to be sought in using and seeing it in action There is no need to make clear the reason for each rule of calculation to the pupil before he starts to use it Mathematics is a language, but it is now generally accepted that children should be taught to talk and read a language before they begin to learn the grammar Boys and men become interested in machinery by seeing it in action and learning to use it Then, if they are of an inquiring turn of mind, they find out how it works If a boy, in the course of learning to use logarithms, gradually learns and understands a coherent body of facts about them, he has learnt some mathematics, even before he finds out that it all depends on indices This, suggested Prof Newman, is the essence of axiomatic mathematics that the systematic development of deductions from abstract laws, and the study of the use that can be made of them, make a branch of mathematics

In another session members heard a vivid description of the Southampton Port Operation and Information Service, with papers by Captain J Andrew, harbour master at Southampton, and Mr A L P Milwright, head of the Ministry of Transport Radar Research Group at the Admiralty Signal and Radar Establishment

Mr Milwright gave a technical description of the radar installation and Captain Andrew explained some of the valuable services that were being rendered in the co-ordination of the movements of shipping

The major session on April 10 was occupied with a discussion of the Association's report, recently published, on mathematics in secondary modern schools

The report is particularly concerned with the mathematical ideas and teaching methods which are considered suitable for the great bulk of the secondary school population between 11 and 15 years of age These children may have shown no earlier sign of readiness for mathematics as an abstract study, or at least have not achieved the attainments in arithmetic traditionally associated with the ablest of their age group There was no intention of offering a specific syllabus of work suited to modern school pupils in general, since circumstances and personal qualities vary so greatly The report does, however, suggest a wide variety of possible approaches to secondary school mathematics, and problems of organization, including syllabus making and the use of examinations, are fully dealt with

The report emphasizes the need for continuity in teaching the subject, and stresses the dependence of work in the secondary school upon that done in the primary school Furthermore, the secondary school is increasingly influenced by the approaching end of full-time schooling and by the demands of adult life as well as those of individual growth and need The pupil's own sense of values is increasingly based on his estimate of what will serve him in good stead in the future, rather than on what will bring him immediate satisfaction and approval The report pays particular attention to the practical topic as a teaching method and to remedial work

During the discussion, Dr J J B Dempster, deputy chief education officer at Southampton, said that greater contact between teachers in secondary modern schools and lecturers in technical colleges was imperative The link between these institutions is tenuous because it is only recently that they have been in contact at all

The stimulus and incentive of a possible future in technical education for the secondary modern school leaver could, however, help to raise the standard of mathematical teaching in the modern schools Dr Dempster believed that concentration on the more able children was necessary, but he hoped that we may ultimately get rid of the attitude that stresses calculations, putting in its place the idea of mathematics as information If pupils could be given a 'revelation', a sudden awareness of what mathematics is about, much of the frustration felt by them and by their teachers might disappear

A description of the *Pegasus* digital computer at the University of Southampton was given by Dr G N Lance, and this was followed by a paper by Dr J P Cleave on the translation of languages by machine Dr Cleave explained that the science of mechanical translation is now well established, particularly in the U S S R , the United States and Great Britain Stimulus to research comes from the presence of vast quantities of foreign technical (legal, economic, scientific, etc) literature, which, through sheer volume, is beyond the capabilities of human translators Human translators are rare, costly and relatively inefficient , they may offer a stylistically polished work but it is often technically inexact The specialist can however, cope well with a crude translation provided the key technical terms are translated exactly Dr Cleave proceeded to show the magnitude of the task, explaining that a programme for mechanical translation must at least contain a dictionary of which a reasonable minimum working capacity is estimated at 10,000 words This requires a reasonably fast access store of at least 20,000 locations, which is several times larger than fast storage devices now available In addition, the programme must include a series of instructions defining the translation operations in terms of shifting and comparison of symbols Inflected languages and compound words, particularly the latter in the German language, also present problems The present development of mechanical translations shows the extent to which the science has already been brought with inadequate equipment When larger-scale storage techniques are perfected, translation will become a practical science

Other papers presented at the conference were on "Plaited Polyhedra" by A R Pargeter, and the "Mechanics of the Fun Fair" by Wing-Commander T R Cave-Browne-Cave

At the business meeting proposals to inaugurate an examination for a diploma in mathematics were welcomed Detailed syllabuses have still to be prepared, but the intention is that teachers (and perhaps others) might obtain a qualification by two years part-time study beyond the advanced level of the General Certificate of Education It is anticipated that the next annual meeting of the Association will establish the diploma, the first examinations for which may be held in 1961

Elected as president for the coming year was Miss L D Adams, a former member of the Schools' Inspectorate Mr F W Kellaway and Miss W A Cooke were re-elected as honorary secretaries, and Prof R L Goodstein as librarian and editor of *The Mathematical Gazette* The new honorary treasurer will be Mr M W Brown, in succession to Mr J B Morgan, who has held office for more than ten years

POSTGRADUATE TRAINING IN THE PUBLIC HEALTH ASPECTS OF NUCLEAR ENERGY

THE existence of many newly developed sources of nuclear radiation, the greatly increased utilization of radioisotopes, and the disposal of radioactive wastes from nuclear fission are factors which constitute a risk not only for those who work with radiation sources and radioactive material but also for the general public The dangers are known and every effort must be made to limit them to the minimum , this will be largely by prevention Workers in public health must, therefore, have appropriate knowledge of those aspects of the nuclear-energy field affecting their own responsibilities, and must be ready, where necessary, to interpret this knowledge to the general public The World Health Organization Committee on Professional and Technical Education of Medical and Auxiliary Personnel was asked to consider the subjects which should be included in the training syllabuses for medical public health officers and other professional public health workers, to determine what degree of knowledge the various members of the public health team should possess, and to indicate suitable methods of providing instruction for personnel who have finished their formal training and are already in service

In the introductory pages of its fourth report* the Committee discusses the problems of measuring radiation and of elucidating its biological effects The public health aspects of peacefully used nuclear energy are then considered in their implications for the community , they are analysed as (*a*) positive aspects (that is, diagnosis, and therapy with radioactive substances , tracer uses of isotopes in biology, medicine, industry and agronomy , food and drug preservation and sterilization) , (*b*) negative aspects (that is, protection from the routine hazards of radiation in medicine and industry , precautions against reactor accidents, disposal of radioactive effluents), and (*c*) public health legislation on the control of such hazards

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* World Health Organization Technical Report Series No 154 Post-Graduate Training in the Public Health Aspects of Nuclear Energy Fourth Report of the Expert Committee on Professional and Technical Education of Medical and Auxiliary Personnel Pp 53 (Geneva World Health Organization, London H M Stationery Office, 1958) 2 Swiss francs, 3*s* 6*d* , 0 60 dollars

The Committee summarizes the responsibilities, in relation to the use of nuclear energy, of personnel in the various health disciplines—health officers, hospital administrators, industrial hygiene workers, sanitary engineers of all types, veterinary public health workers, and laboratory and other technical personnel, instruction in the field of nuclear energy should speedily be incorporated in graduate and postgraduate courses for public health students The Committee recommends that the teaching content of the courses should cover physical principles, biological principles, the application of nuclear energy and radiation, hazards and protection, each of these subjects is considered at four teaching levels—an orientation course, an introductory course, an advanced course, and a specialist course The compilation of a handbook of radiological health data, to serve as a reference manual for public health workers, was also proposed

RECORDING THE POSITIONS OF MICROSCOPICAL OBJECTS

MORE than a century has elapsed since Maltwood[1] introduced his admirable 'finder', which enabled the user to record the positions of objects on microscopical slides Not many of the original Maltwood finders survive Interest in the subject revived recently, when careful instructions for making similar finders were published[2]

An instrument of the same sort as Maltwood's, but differing in details, has now been put on the market by Graticules Ltd under the name of the 'England Finder' This resembles in appearance an ordinary microscopical slide When it is viewed under a low power of the microscope, it is seen to be divided by rulings into a large number of squares In the centre of each square a circle is inscribed, each circle is distinguished by a letter and a number (for example, *P*31) The part of each square lying outside the circle is divided by vertical and horizontal straight lines into four equal parts, situated north-west, north-east, south-west and south-east of the circle, these are labelled 1, 2, 3 and 4, respectively The letters and numbers are clearly legible

When an interesting object has been found on a microscopical slide, it is brought into the centre of the field of view It is necessary that the slide should lie against the horizontal bar of the mechanical stage, and should be pushed up against the lateral stop The slide is then removed and the finder placed in exactly the same position The finder is examined with a low-power objective If one of the circles covers the centre of the field of view, its letter and number are recorded If one of the corners of a square covers the centre, its number is recorded in addition to the letter and number of the circle enclosed in that square (for example, *P*31/2) One can at any time find the interesting position on the slide by bringing the recorded place on the finder into position and then replacing the finder by the slide

It is claimed by the manufacturers that their finders are all marked in exactly the same way, so that all give the same reading with the same object

Those who have tried both verniers and finders are likely to favour the latter, because the letters and numbers are so easily read, and also because the recorded positions do not relate to one particular microscope only, but are applicable to any instrument provided with a mechanical stage (or some substitute for this) The only disadvantage is that the slide must be removed temporarily while the reading is being made The 'England Finder' can be strongly recommended

J R BAKER

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[1] Maltwood, T, *Trans Micro Soc*, 6, 59 (1858)

[2] Bradbury, S, Galbraith, W, and Lyster, M E, *Quart J Micro Sci*, 97, 197 (1956)

VERY LOW-FREQUENCY SPECTRA OF ATMOSPHERICS PROPAGATED THROUGH THE IONOSPHERE

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IT has been known for many years that atmospherics in the very low-frequency band can propagate to great distances In recent years, however, there has been a renewed interest of this problem, many investigators have found an evidence of a pronounced absorption band at 2–4 kc /s, while for frequencies around 10 kc /s there is little attenuation Extensive studies have been made on wave-form characteristics as well as the amplitude frequency spectra of individual atmospherics[1,2] Their results showed distinct frequency spectra of atmospherics, indicating the existence of an appropriate mode of propagation and of the strong selective attenuation due to ionospheric influences A new theory of very low-frequency ionospheric propagation, known as the mode theory, was suggested by Budden[3] in 1951, and further theoretical studies have been pursued, especially by Wait[4,5], who made an elaborate computation on the mode of ionospheric propagation and showed that the characteristics predicted by the theory accord well with the experimental facts

In this investigation, an attempt was made to obtain a more complete experimental proof of the mode theory A new apparatus was developed recording continuously the frequency-spectrum of atmospherics Two sets of radio spectroscopes covering the frequency ranges 1–10 kc /s and 5–70 kc /s were used, each set consisted of the conventional very low-frequencies atmospherics receiver of superheterodyne type, a frequency scanning device with a display unit comprising a cathode-ray oscillograph and a photographic motion camera The bandwidths of the scanner for the two very low-frequency bands were ± 250 c /s and ± 600 c /s, respectively, and its frequency-scanning rate was about 10 c /s Special attention was being paid to obtaining a flat frequency-response of the receiver over the sweep-frequency range and a sharp cut-off for the rest of the frequencies

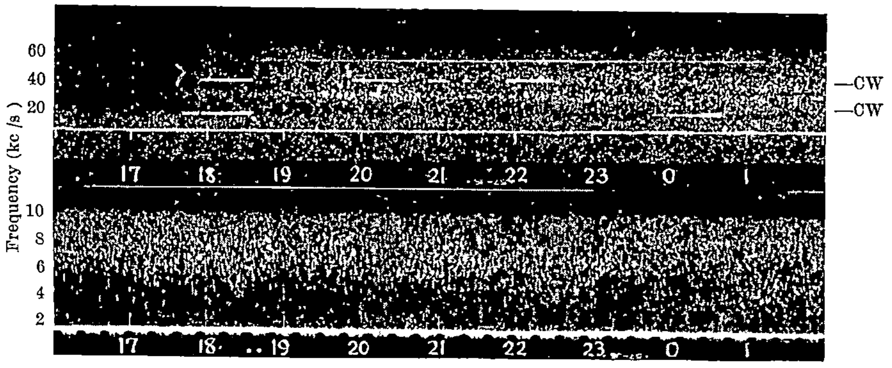


Fig. 1. Frequency spectra of very low-frequency atmospherics. December 14, 1958

The record was calibrated by frequency markers at intervals of 2 kc./s. and 10 kc./s. applied every hour.

Observations of atmospherics using these spectroscopes have been carried out here since June 1958. Simultaneously, the intensity of atmospherics at 27 kc./s. has also been measured continuously. The results so far obtained appear to provide an excellent experimental confirmation of the mode theory.

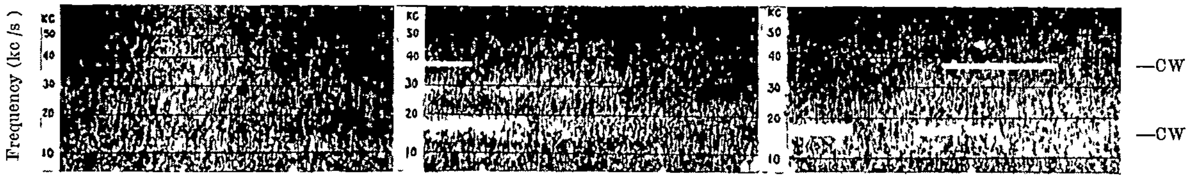
Typical records are reproduced in Fig. 1, in which the light and dark portions indicate intense atmospherics and weak or no atmospherics respectively. Signals from radio stations are also recorded, which appear as white straight lines at, for example, frequencies of 17 and 38 kc./s. It is evident from these records that there exists a frequency-band of strong absorption for atmospherics propagation around 2–4 kc./s. The intensity of atmospherics is maximum at about 10–20 kc./s. and it decreases towards higher frequencies with undulating peaks.

In discussing these frequency-spectra of atmospherics, it must be remembered that the period of sweep frequency (order of 0·1 sec.) is not long enough to cover the whole spectrum of individual atmospherics, which are usually less than a few milliseconds in duration. However, if it is assumed that numerous atmospherics are occurring randomly within a short period of time, a long time-exposure of the film should reveal the relative amplitude-frequency spectrum in a statistical sense.

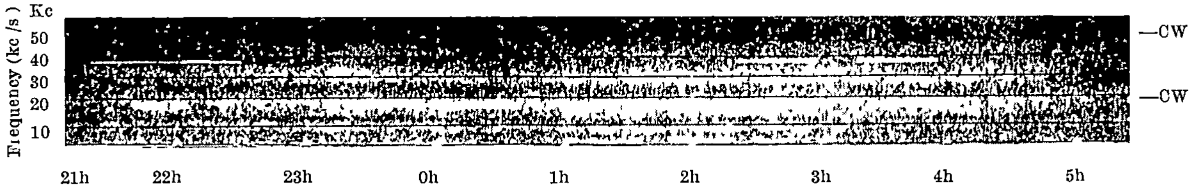
By examining the records, it is found that night-time atmospherics are much less intense and extend to wider frequencies than those of day-time. There exists a strong absorption band at 2–4 kc./s. and certain clear strips of intensity in the higher frequencies, which are changing regularly with the local time. As shown in Fig. 2*a* the short distance atmospherics (probably from sources less than 500 km. distant) do not show such frequency characteristics. Therefore, the general features stated above should be restricted to long distance atmospherics, which may be strongly influenced by the ionospheric conditions. The observed fact that the maximum intensity of atmospherics lies in the frequency range around 10 kc./s. confirms the earlier result, which was based on numerous studies of wave-forms and field intensity measurements of distant atmospherics.

By scanning the film records with a photo-electric scanner, the photographic pattern displayed by intensity-modulated plots was converted to a measure of the amplitude of the atmospherics. Typical amplitude-frequency spectra at night- and day-time are shown in Fig. 3. The night-time spectrum has its maximum at about 8–10 kc./s. and the intensity decreases with frequency in undulating peaks, while the day-time spectrum has a smooth lower maximum at about 15 kc./s. These two types of the spectrum interchange rather distinctly at local sunrise and at sunset. The night-time pattern is shifted towards higher frequencies as shown in Fig. 2*b* although the sunset transition is less clear.

These characteristics of the amplitude-frequency spectrum of atmospherics appear to support the wave-guide mode theory whereby very low-frequency radio waves are propagated to great distances by multiple reflexions in the wave-guide bounded by the Earth and the ionosphere[3,4]. An essential part of this theory is the existence of definite cut-off frequencies in the mode of wave-guide propagation. If we consider space between the ground and ionosphere as a wave-guide, then the cut-off wavelength is given by $2h/n$, where n is the integer specify-



(*a*) Short-distance atmospherics (*b*) Local sunrise (*c*) Solar flare



(*d*) Night-time frequency-spectrum of atmospherics

Fig. 2. Frequency-spectra of very low-frequency atmospherics of ionospheric propagation

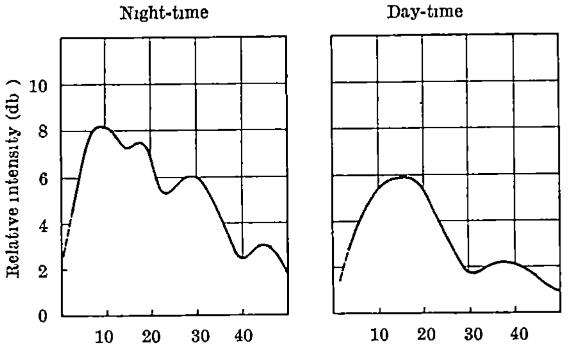


Fig 3 Typical amplitude-frequency spectra of distant atmospherics

ing the number of the mode and h is an effective reflecting height of the ionosphere When the boundary of the wave-guide is not perfectly conducting, as is the case with the actual ionosphere, the cut-off wave-length is not sharply defined and the effective reflecting height of the ionosphere would become higher

From the above consideration, the absorption band observed at 2–4 kc /s may be regarded as the effect due to an ionospheric cut-off of the fundamental mode, as suggested by Budden The dawn effect of the frequency-spectrum, which appears as the shifting of the maximum intensity bands towards higher frequencies, could be explained as the lowering of the ionospheric height or else the increase of the conductivity in the lower ionosphere On the other hand, it is already known from a number of experiments that the reflecting height varies considerably from 90 km at night to 70 km during the day[6] Therefore, this agrees well with the present conclusion

There is an another interesting fact, lending further support to the mode theory This is the relation between the sudden enhancement of atmospherics (SEA), and sudden ionospheric disturbances (SID) An intense solar flare occurred at 13h 35m , August 16, 1958, which was associated with a pronounced sudden enhancement of atmospherics in the record of field intensity of atmospherics at 27 kc /s The record of frequency-spectrum during this period is reproduced in Fig 2c A sudden shift of the frequency-spectrum at the beginning of the solar flare is evident , the band of strong intensity was around 10–20 kc /s up to the beginning of the flare, as is usual in day-time, and then at 13h 35m the band of strong intensity shifted towards higher frequencies of 15–30 kc /s Consequently, at the higher frequencies in the very low-frequency band the intensity of distant atmospherics is enhanced, while at the frequency about 10 kc /s or less a sudden reduction in intensity occurs This confirms the result of Gardner[7] Since it is known that during sudden ionospheric disturbances the electron density in the lower ionosphere is increased and its height is lowered considerably, these facts are consistent with the explanation that the reduction of field intensity in the lower very low-frequency band is caused by the cut-off moving towards slightly higher frequencies, while in the frequencies above the cut-off the intensity is enhanced considerably owing to the good reflexion condition in the lower edge of the ionosphere

[1] Chapman, F W , and Matthews, W D , *Nature*, **172**, 495 (1953)
[2] Chapman, F W , and Macario, R C V , *Nature*, **177**, 930 (1956)
[3] Budden, K G , *Phil Mag* , **42**, 1 (1951)
[4] Wait, J R , *Proc Inst Radio Eng* , **45**, 760 (1957)
[5] Wait, J R , *Proc Inst Radio Eng* , **45**, 768 (1957)
[6] Waynick, A H , *Proc Inst Radio Eng* , **45**, 741 (1957)
[7] Gardner, F F , *Phil Mag* , **41**, 1259 (1950)

COMPARATIVE EFFECTS OF HEAT ON CHROMATOGRAPHY AND ULTRA-VIOLET ABSORPTION OF DEOXYRIBO- OR RIBO-NUCLEIC ACIDS

By Dr SAUL KIT

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THERE is considerable evidence to suggest that the deoxyribonucleic acids (DNA) represent linear, unbranched molecules in which two complementary helical polynucleotide chains are twined around one another[1,2] As proposed by Crick and Watson[3], the two chains are held together by hydrogen bonds between bases, each base being joined to a companion base on the other chain The pairing of bases is specific, adenine going with thymine and guanine with cytosine Lawley[4] has observed that when solutions of deoxyribonucleic acid are heated in neutral saline solution at temperatures of 80° or greater and then cooled to room temperature, the optical density in the ultra-violet is increased by about 30 per cent Table 1 illustrates this effect for various samples of tumour or normal spleen deoxyribonucleic acid In the presence of sodium ions, there is no change in the shape of the absorption curves but the extinction coefficient increases at the wave-lengths 230–280 mμ Since it is unlikely that such treatment breaks phosphodiester bonds, the increased optical density has been attributed to (*a*) the breaking of the hydrogen bonds between pairs of bases and the separation of sections of the two polynucleotide chains , (*b*) a rearrangement of the

Table 1 Effect of Heat on Nucleic Acid Absorption in Ultra-violet

Tissue	Deoxyribonucleic acid Per cent of control value	Ribonucleic acid Per cent of control value
Ehrlich	128	115
Lettre–Ehrlich	137	111
Lettre–Ehrlich (sucrose–citrate extract)	—	109
6C3HED-DBA to *C3H*	130	98
6C3HED-DBA	—	113
6C3HED	134	
E9514A	135	
Leukæmia No 10	135	
Spleen	128	

Heated 1 hr at 100° at pH 7, 0 01 M or 0 05 M sodium chloride, 0 005 per cent solution of nucleic acid and then cooled to room temperature Optical density read at 258 mμ with Beckman *DK*-2 spectrophotometer more flexible single chains to configurations in which the purine and pyrimidine rings are no longer superimposed[4] The conclusions of Lawley are generally supported by physical chemical studies of solutions of heated deoxyribonucleic acid although the exact results which are obtained depend on the concentration of the acid or ions in the solution[3,5]

The chromatographic profiles on cellulose-anion exchange resins of deoxyribonucleic acid are also markedly modified by brief periods of heat treatment[6] (Fig 1) Most of the heated deoxyribonucleic acid can be eluted from the resins by 0 8 M sodium chloride although higher salt concentrations and increased alkalinity are required for the elution of the untreated samples As the relative ease of elution of mixtures of deoxyribonucleic acid from anion exchangers is in part a function of the molecular weight or state of aggregation of the molecules[7-9] the chromatographic results suggest that molecules of reduced molecular weight are generated as a result of the cycle of heating and cooling

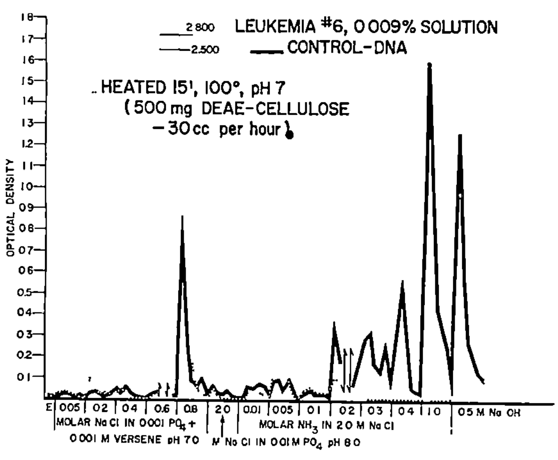

Fig 1 Effect of heat on chromatography of leukæmia No 6 deoxyribonucleic acid Approximately 3 mgm of the acid was applied to each column Recovery of deoxyribonucleic acid on control column, 111 per cent, heated sample, 105 per cent 5 c c aliquots collected, 6 aliquots per eluting solution

Although ribonucleic acids from many sources have been examined by physical methods within the last few years, no clear-cut and consistent picture of the configurational properties has materialized[10,11] It is therefore noteworthy that the effect of heat on the optical density and chromatographic profiles of ribonucleic acid are in marked contradistinction to that of deoxyribonucleic acid

Ribonucleic acid was prepared from the same sources as the samples of deoxyribonucleic acid by modifications of Kirby's method[12,13] The ribonucleic acid was extracted with 8 volumes of 0 01 M sodium chloride and 8 volumes of 90 per cent phenol containing 10 per cent *m*-cresol All operations were carried out in the cold room (about 6°) and the ribonucleic acid was dissolved in 0 01 M sodium chloride rather than water at each of the reprecipitation steps When these samples were heated for 1 hr at about 100°, in neutral saline solutions (0 05–0 5 M sodium chloride) a 20 per cent increase of the optical density was observed (Fig 2) Hall and Doty found a similar increase in the case of calf liver microsomal ribonucleic acid[11] On cooling to room temperature, the optical density is reduced to about 10 per cent above the control value (Table 1) These observations are consistent with the view that intra- and inter-chain attractions in ribonucleic acid arise from hydrogen bonding between purine and pyrimidine bases, but that the fraction of the base pairs involved in hydrogen bonding is relatively unchanged by the heating cycle Indeed, the first heating cycle of freshly prepared ribonucleic acid shows the same results as successive cycles, in contrast with deoxyribonucleic acid, where the optical density never returns to the original value after the first heating[11] Ribonucleic acid which was prepared from a 0 25 M sucrose–0 01 M citrate extract of the tumour cells gave the same results after heating as the total ribonucleic acid of the cells (Table 1)

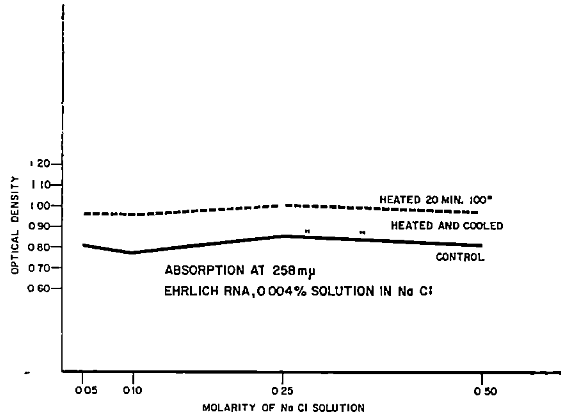

Fig 2 Effect of heating (100° for 20 min) and subsequent cooling to room temperature on the optical density at 258 mμ of Ehrlich ascites tumour ribonucleic acid The acid samples were dissolved in neutral saline solutions (0 05 M–0 5 M sodium chloride) at a concentration of 0 004 per cent ribonucleic acid The Beckman *DK*-2 spectrophotometer was used to record the optical density between 300 and 240 mμ

Preparations of ribonucleic acid have been chromatographed after the samples were heated in neutral salt solution for 15 min at 100° and cooled to room temperature (Fig 3) Again, unlike that of the deoxyribonucleic acid, the chromatographic profiles of the heated ribonucleic acid were unchanged from that of the controls These results add validity to recent suggestions that the ribonucleic acid consists of a single-stranded polynucleotide chain[11,14-16] They are also consistent with the speculative models in which a single-stranded molecule of ribonucleic acid is visualized as functioning in the initial transfer of coded information from double-stranded molecules of deoxyribonucleic acid[17,18]

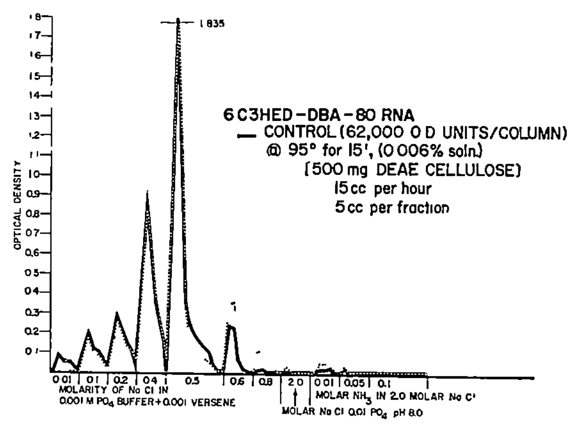

Fig 3 Effect of heat on chromatography of tumour (*6C3HED-DBA*/80)-ribonucleic acid Approximately 3 mgm of the acid were applied to each column Recovery of ribonucleic acid control, 75 per cent, heated sample, 78 per cent

I wish to acknowledge the technical assistance of Arthur Gross, Frank Broo and Henry Szwartz.

This work was aided in part by grants from the American Cancer Society (*P*-35), the Leukemia Society Inc, and the National Cancer Institute (*C*-4238)

[1] Crick, F H C, *Proc U S Nat Acad Sci*, **40**, 756 (1954)

[2] Shooter, K V, "Prog in Biophys and Biophys Chem", **8**, 309 (1957)

[3] Crick, F H C, Symposium on the Chemical Basis of Heredity, ed by W D McElroy and B Glass, 532 (Johns Hopkins Press, Baltimore, 1957)

[4] Lawley, P D, *Biochim Biophys Acta*, **21**, 481 (1956)

[5] Dekker, C A, and Schachman, H K, *Proc U S Nat Acad Sci*, **40**, 894 (1954)

[6] Bendich, A, Pahl, H B, Rosenkranz, H S, and Rosoff, M, *Symp Soc Exp Biol*, **12**, 31 (1958)

[7] Bendich, A, Pahl, H B, and Beiser, S M, *Cold Spring Harbor Symp Quant Biol*, **21**, 31 (1956)

[8] Rosoff, M, di Mayorca, G, and Bendich, A, *Nature*, **180**, 1355 (1957)

[9] Bradley, D F, and Rich, A, *J Amer Chem Soc*, **78**, 5898 (1956)

[10] Watson, J D, Symposium on the Chemical Basis of Heredity, ed by W D McElroy and B Glass, 552 (Johns Hopkins Press, Baltimore, 1957)

[11] Hall, B D, and Doty, P, First Symposium, Biophysical Society, ed by R B Roberts, 27 (Pergamon Press, New York, 1958)

[12] Kirby, K S, *Biochem J*, **64**, 405 (1956)

[13] Kirby, K S, *Biochem J*, **66**, 495 (1957)

[14] Hart, R G, *Biochim Biophys Acta*, **28**, 457 (1958)

[15] Gierer, A, *Z Naturforschung*, **13b**, 477 (1958)

[16] Commoner, B, Shearer, G B, and Strode, C, *Proc U S Nat Acad Sci*, **44**, 1117 (1958)

[17] Zubay, G, *Nature*, **182**, 112 (1958)

[18] Stent, G S, "Adv in Virus Res", **5**, 95 (1958)

MECHANISM OF THE ATHEROGENIC ACTION OF EXCESS HYDROCORTISONE

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IN animal experiments, adrenocortical steroids can act by eliciting vascular damage[1–3] In man, high thereapeutic doses of adrenocortical steroids lead to arteriosclerosis In Cushing's syndrome, excess adrenocortical steroids produce severe arteriosclerosis Other factors possibly involved in atherogenesis, for example, steroid diabetes, and 'stress', show hyperplasia and hyperfunction of the adrenal cortex, and have been assumed to act via the adrenal cortex Therefore, progress achieved in the elucidation of the mechanism of action of adrenocortical steroids might shed new light on problems of atherogenesis

The protein-catabolic effect of C-11-oxygenated steroids, and the stimulation of glyconeogenesis from amino-acids are firmly established results of experiments on animals and man, but no conclusive evidence had been obtained on the question whether glucocorticoids affect the rate of oxidation of glucose On one hand, glucocortical hormone promotes the normal function and survival of the intact cell, as demonstrated by its action on adrenalectomized 'adynamic' animals, and in Addison's disease, but on the other hand, excess glucocorticoid action causes inhibition of growth and of wound healing, and disruption of cellular structure, for example, destruction of lymphatic tissue and of thymus

An investigation into the direct action of glucocorticoids on respiration and aerobic glycolysis of cultured cells has been carried out, in order to obtain more information on the action of cortical steroids on energy production The methods used were described elsewhere[4] In one group of experiments, a single dose of hydrocortisone in high concentration added to a cell suspension in the Warburg vessel before its transfer to the manometric bath caused inhibition of respiration coupled with increase of aerobic glycolysis (Table 1) Hydrocortisone in the same concentration added in a single dose to cultured cells caused growth inhibition averaging 40 per cent for 125

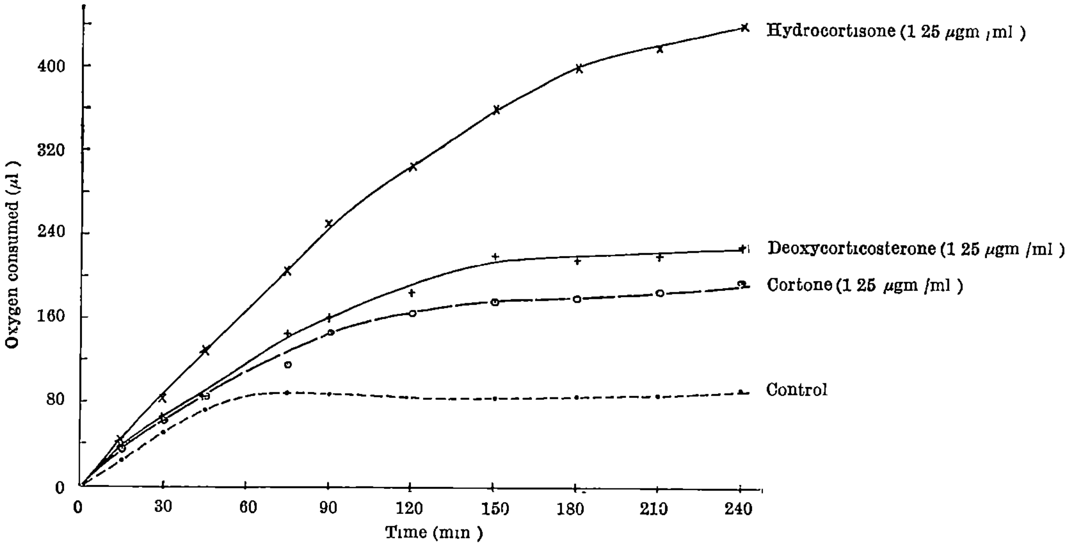

Fig 1

Table 1 Action of a Single Growth-inhibitory Dose of Hydrocortisone on Respiration and Aerobic Glycolysis

No	Concentration γ/ml *	Oxygen consumed (μl) after hr 1	2	3	4	5	Carbon dioxide (μl) evolved after hr † 1	2	3	4	5
1	150 0	−81 −115	−128 −166	−144 −214	−143 −221	— —	+42 0	+33 0	+28 0	+19 0	— —
2	125 0	−55 −88	−102 −155	−130 - 225	−146 −258	−146 −280	+88 0	+40 0	+72 0	+82 0	+86 0
3	100 0	−87 −99	−141 −175	−163 −187	−253 −269	— —	+46 0	+131 0	+143 0	+123 0	— —
4	60 0	−64 −78	- 72 −110	−106 −139	−113 −149	— —	+52 0	+138 0	+149 0	+169 0	— —
5	125 0	−13 −41	−50 −157	−62 −240	−62 −313	−73 −362	+69 0	+110 0	+83 0	+65 0	+45 0
6	125 0	−19 −44	−28 −70	−47 −98	— —	— —	+96 +21	+185 +50	+134 +25	— —	— —
7	125 0	−21 −40	−33 −57	−36 −84	−45 −67	— —	+68 +16	+113 +40	+153 +25	+141 +17	— —

* Single dose added to the Warburg flasks
† After subtraction of respiratory carbon dioxide

γ/ml, as determined by enumeration of cell nuclei In a second group of experiments, hydrocortisone in concentrations of about 0 50–1 50 γ/ml added to cultures three times at intervals of 2–3 days caused stimulation of respiration (Table 2) The mineralocorticoid deoxycorticosterone showed a considerably smaller effect than hydrocortisone (Fig 1)

These results indicate that hydrocortisone in lower concentrations, by stimulating respiration increases energy production and thus enhances work efficiency In excess hydrocortisone, respiration is depressed, glycolysis increased, and sugar is also synthesized from amino-acids At the same time, inhibition of protein synthesis by excess hydrocortisone may lead to impairment and damage of cellular structure, perhaps by depletion of structural protein In insufficient respiration, hydrocortisone in high concentration appears to be instrumental in causing a shift towards more anaerobic utilization of sugar This would agree with findings of hyperfunction and hypertrophy of the adrenal cortex during strenuous work for which anaerobic energy is utilized[5]

It has been found that fibroblasts derived from various organs produce *in vitro* various patterns of acid mucopolysaccharides[6–8] The chemical differentiation of fibroblasts is maintained for long periods of time only in primary cultures (up to now for more than two years), while replicate cultures of cell strains of mesenchymal origin irreversibly lose the ability to produce mucopolysaccharide Indeed, there is a parallelism between loss of chemical differentiation (that is, production of mucopolysaccharides) and increase of ratio of aerobic glycolysis to respiration[9] It is suggestive that depression of respiration (coupled with release of aerobic glycolysis), leading to loss of differentiation, may be involved in the atherogenic effect of excess hydrocortisone, which has been shown to depress respiration and stimulate anaerobic metabolism In fact, depression of oxidative metabolism in arteriosclerotic[10] and in aged[11] arteries has been reported Depression of respiration, with release of aerobic glycolysis, in addition to vascular damage, could thus be demonstrated in arteries of rats treated with large atherogenic doses of hydrocortisone

Two more diseases of endocrines which normally are involved in carbohydrate metabolism, namely, thyroid and islets of Langerhans, may also become involved in the pathogenesis of arteriosclerosis Myxœdema invariably leads to severe arteriosclerosis There is evidence of increased susceptibility of the thyroid-deficient animal and person to arteriosclerosis In senescent animals, the thyroid is reduced in size[12] Aloxan diabetes leads to arteriosclerosis in rats[13] Diabetes considerably increases the incidence of arteriosclerosis in man A considerable degree of hypertrophy of the adrenal cortex, resembling adenomas in Cushing's syndrome, has been found in diabetic arteriosclerosis[14] The connexion between

Table 2 Action of Lower Concentrations of Hydrocortisone on Respiration

No	Concentiation γ/ml *	Oxygen consumed (μl) after hr 1	2	3	4	5
1	1 50 0	−181 −133	−276 −190	−374 −239	−474 −271	−573 −282
2	1 50 0	−193 −141	−363 −241	−492 −300	−668 −346	— —
3	1 50 0	−130 −94	−219 −166	−290 −193	−360 −226	— —
4	2 00 0	−176 −97	−379 −227	−524 −313	−664 −346	— —
5	0 50 0	−78 −67	−123 −96	−150 - 104	−177 −109	— —
6	1 25 0	−72 −47	−100 −60	−129 −64	−145 −81	−152 −76

* Added to the cultures three times.

depression of respiration and hypersecretion of adrenal cortex can also be seen in the demonstration of increased adrenal weights in rats maintained at a depressed oxygen supply[15].

It has been assumed that glycolysis, *ceteris paribus*, may provide a more adequate environment for fatty acid synthesis than respiration. In fatty acid synthesis, acetyl-S-coenzyme *A* is reduced by reduced diphosphopyridine nucleotide and the reaction products are diphosphopyridine nucleotide, beta-hydroxybutyryl-S-coenzyme *A* and reduced coenzyme *A*. The cycle of reactions is repeated eight times until stearyl-coenzyme *A* is formed. Fatty acid synthesis requires thus the participation of reduced pyridine nucleotide. Since oxidation of lactate is coupled with reduction of diphosphopyridine nucleotide, the ability of lactate to regenerate reduced pyridine nucleotide might be an important factor in stimulating lipogenesis[16,18]. This assumption is compatible with the finding that in tissue-cultured cells in which relatively high glycolysis is a characteristic feature of carbohydrate metabolism, there is a striking tendency to augmentation of cytoplasmic lipid.

Other examples show a relationship between high glycolysis and fatty acid synthesis. Cells in tissue culture exposed to the action of hydrocortisone in *high* concentration show more cytoplasmic lipid than control cultures[19-21]. Large amounts of higher fatty acids, in addition to lactic acid, were found in worms producing about six times more glycogen in fermentation than in respiration[22]. There is a striking accumulation of lipid in the cytoplasm of chondrocytes in cartilage with high rate of glycolysis. It is tempting to correlate the high glycolysis rate found in normal human arteries—51 per cent of total glucose utilization[23]—with the accumulation of lipid in human arteries of healthy individuals of all ages, including infants[24]. It is suggestive that the amount of lipid in arteries increases with the increase of ratio of aerobic glycolysis to respiration.

Several kinds of tissues with predominantly anaerobic metabolism are known, such as, for example, lens, cartilage, human sperm, intestinal mucosa. Other tissues, such as heart muscle, have an almost exclusively oxidative metabolism. Still other tissues, for example, testis, brain, medulla of kidneys, pituitary, arteries, possess both respiratory and fermentative systems[25]. They possess a regulative device which enables them to use either their anaerobic or their aerobic system. They are equipped with a switch mechanism (their 'Pasteur effect') which keeps fermentation from functioning so long as the respiratory system supplies sufficient energy, but may throw it into operation in emergency when energy supply from respiration is either blocked or is too slow. It has been presumed that hormonal action might be involved in such regulations[25]. Muscles suddenly put under strain must rely predominantly on a supply of anaerobic energy[25,26], and there is no basic difference in energy metabolism between striated and smooth muscles[28]. There are indications that adrenocortical steroids may be instrumental in the switch from oxidative to fermentative metabolism[27]. Anaerobic glucose utilization was found to be, to a significant extent, the source of energy for the work of arteries[23]. It is suggestive that the ratio of aerobic glycolysis to respiration in arteries depends on the extent of blood flow needed for the organ supplied by the arteries, and on the oxygen tension of the blood.

Let us consider as an example the coronary arteries of the heart. The metabolism of the heart muscle is strictly oxidative. Of the total myocardial oxygen used, 16 per cent is for glucose oxidation, 17 per cent for lactate oxidation and 67 per cent for oxidation of fatty acids which are derived from blood lipids[29]. Alimentary lipæmia would result in an increase in the contribution of fatty acids to the oxygen consumption of the heart. The oxygen extraction of the heart muscle is maximal. Therefore, the response of the heart to increased demands of oxygen must consist in an increase of coronary blood flow. The response to anoxia with lactic acid production in the heart muscle is obtained only in its severest forms, for example, in hæmorrhagic shock, or ventricular fibrillation. An increase of oxygen demand during exercise necessitates an increase of coronary blood flow, which in part must be carried out by increased work of the coronary arteries. This additional work of the arteries requires an additional supply of energy. The source of such additional energy cannot be aerobic since it is designed to make possible production of aerobic energy by increased blood flow. (Blood flow through the vasa vasorum also depends on heart muscle work.)

It must thus be postulated that the coronary arteries are able to increase the utilization of anaerobic energy when increased flow to the heart muscle is required for the supply of more oxygen. In fact, as has recently been found[23], anaerobic energy accounts for 51 per cent of the total energy production in arteries. It is suggestive that the extent of anaerobic energy production in the coronaries increases in proportion to the extent of relative hypoxia. It would appear that so long as the ratio of anaerobic to aerobic metabolism is not too high, their work remains unimpaired. But if certain as yet unidentified steps of oxidative metabolism are permanently depressed, anaerobic metabolism becomes the main source of energy supply, which is less economical and in some respects inferior to the normal arterial metabolism. It may perhaps give rise to increased formation of cytoplasmic lipid. It might eventually impair the functional and structural cellular integrity[30,31]. In that regard, the following possibilities should be considered. Cell differentiation presumably requires the presence of intact organized respiratory enzyme systems. When cells normally deriving part of their energy from oxidation are forced by environmental conditions, such as relative hypoxia or by damage to certain enzymes, to use anaerobic energy only, pathological alterations may eventually result. Increased anaerobic metabolism in the coronaries, stimulated by excess hydrocortisone, is associated with excessive proteolysis, which may cause depletion of functional protein and interfere with re-synthesis of enzyme systems. Extensive depletion of storage and of functional protein under the influence of excess hydrocortisone has been reported[5].

These general concepts, which have evolved in the course of experimental work, were conceived only as a tentative approach to some problems of atherogenesis. They are not new, since they were anticipated in 1876 by Louis Pasteur. The basic difference between respiration and fermentation as expressed in cell morphology and the efficiency of performance of specific cell functions was noted by Pasteur when he described his famous observations as follows: "In the absence of air, yeast cells deteriorate, become granular, form proturbances which disintegrate, and eventually degenerate. Addition of a small quantity

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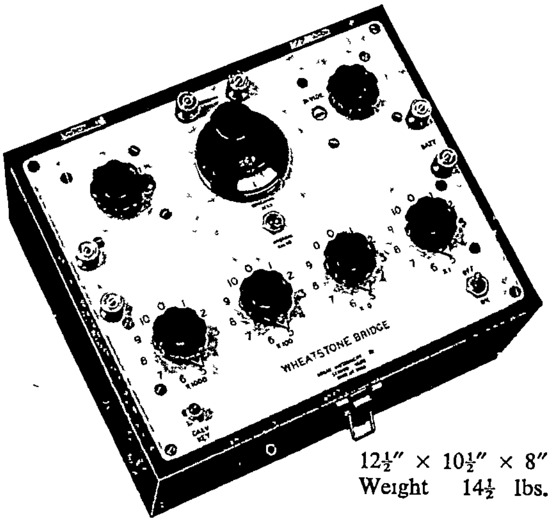

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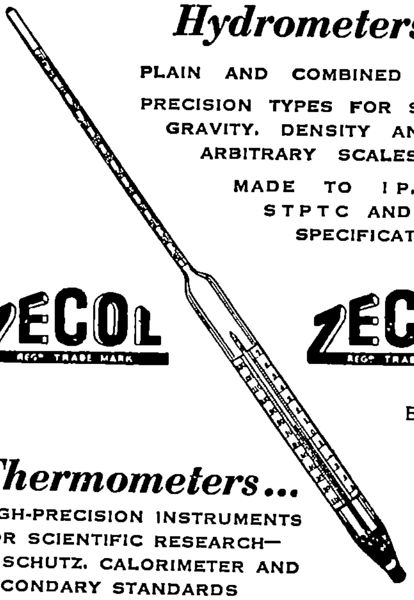

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[1] Masson, G M C , "Atherosclerosis", 99 (U S Nat Acad Sci , Washington, D C , 1955)

[2] Wexler, B C , and Miller, S F , *Science*, **127**, 590 (1958)

[3] Selye, H , and Renaud, S , *Proc Soc Exp Biol Med* , **96**, 512 (1957) , *J Physiol* , **187**, 41 (1956)

[4] Grossfeld, H , *Science*, **127**, 148 (1958)

[5] Kinsell, L W , "Hormonal Regulation of Energy Metabolism" (Ch Thomas, Springfield, 1957)

[6] Grossfeld, H , *Exp Cell Res* , **14**, 213 (1958)

[7] Grossfeld, H , Meyer, K , Godman, G , and Linker, A , *J Biophys Biochem Cytology*, **3**, 391 (1957)

[8] Grossfeld, H , *Proc Soc Exp Biol Med* , **96**, 144 (1957)

[9] Grossfeld, H (in the press)

[10] Kirk, J E , Matzke, J K , Brandstrup, N , and Wang, J , *J Geront* , **12**, 24 (1958)

[11] Maier, M , and Haimovici, H , *Proc Soc Exp Biol Med* , **95**, 425 (1957)

[12] *Experientia*, Supp IX (1956)

[13] Kochakian, C G , "Ciba Foundation Colloquia on Endocrinology", **1** (1952)

[14] N Y Acad Sci Conf on the Influence of Hormones on Lipid Metabolism in Relation to Arteriosclerosis (New York, April 1958)

[15] Sundstroem, K S , and Michaels, G , *Mem Univ of California*, **12** 42 (1942)

[16] Grossfeld, H , Eighth Ann Meet Tissue Culture Assoc , Baltimore, April 1957 (Abstr)

[17] Grossfeld, H , *Experientia*, **14** (10), 371 (1958)

[18] Terner, Ch , *Proc Soc Exp Biol Med* , **96**, 801 (1957)

[19] Grossfeld, H , and Ragan, Ch , *Proc Soc Exp Biol Med* , **86**, 63 (1954)

[20] Holden, M , and Adams, L B , *Proc Soc Exp Biol Med* , **95**, 364 (1957)

[21] Lenti, G , Tortarolo, E , Masolini, G , and Tappero, D , *Folia Endocrin* , **4**, 743 (1957)

[22] Slater, W R , *Biochem J* , **19**, 604 (1926) Brand, T v , *Erg Biol* , **10**, 37 (1934)

[23] Kirk, J E , Efferovo, F G , and Chiang, S P , *J Geront* , **9**, 10 (1954)

[24] Zugibe, F T , and Brown, K D , *Circulation*, **18**, 804 (1958)

[25] Lipmann, F , "Pasteur Effect in Respiratory Enzymes" (Univ Wisc Press, Mad , 1942)

[26] Bang, O , dissertation, Copengagen (1935)

[27] Suzuki, T , Yamashita, K , and Nitamura, T , *Nature*, **181**, 715 (1958)

[28] Szent-Gyorgyi, A , "Nature of Life", 89 (Acad Press, New York, 1948)

[29] Bing, R J , "Harvey Lectures" (Acad Press, New York, 1956)

[30] Baker, B J , "Pituitary–Adrenal Function, 88 (Amer Assoc Adv Sci , Washington, D C , 1950)

[31] Ingle, D J , and Neeks, R C , *Amer J Physiol* , **170**, 77 (1952)

[32] Pasteur, L , "Etudes sur la bière" 240, 247, 254 (Gauthiers, Paris, 1876)

OPTICAL ACTIVITY OF STERCOBILIN AND *d*-UROBILIN

By Prof C H GRAY, P M. JONES, Dr W KLYNE and Dr D C NICHOLSON

Departments of Chemical Pathology at King's College Hospital Medical School, London, S E 5, and at the Post-graduate Medical School, Hammersmith, London, W 12

THE identification of the structural factors responsible for the optical activity of the urobilinoid pigments presents an interesting problem in stereoisomerism Some properties of the five pigments at present known are summarized in Table 1 , their structures are shown in Fig 1 Laevo-rotatory enantiomorphs of *d*-urobilin and *d*-urobilin IXα, which are present in the racemic forms of these pigments, have not yet been isolated (The use of the prefix *d*- to indicate a dextro-rotatory compound is now contrary to standard practice in organic chemistry ; it has, however, become customary in this particular field)

Although the molecular structures of stercobilin and *d*-urobilin are known[8], their stereochemistry and the origin of their optical activity remain obscure Optical activity might conceivably arise from nonplanarity of the system of four pyrrole nuclei , this possibility can, however, be excluded since biliverdin and bilirubin, which have no asymmetric carbon atoms, are not optically active Asymmetric carbon atoms are present in one α-position of each of the terminal pyrrolidone rings (in stercobilin) and pyrrolinone rings (in *d*-urobilin) , in stercobilin there are also asymmetric carbon atoms in the β-positions of the end rings Urobilin IXα may then be either a racemic *d*-urobilin IXα or a meso-like compound in which the two asymmetric carbon atoms exert opposite effects

Stercobilin retains its optical activity even on treatment with warm potassium *t*-butoxide, while *d*-urobilin is rapidly racemized in 1 25 *N* aqueous

Table 1*

Pigment	Source	Molecular formula	λ_{max} for solution of hydrochloride in $CHCl_3$†	$[M]_D$ for hydrochloride in $CHCl_3$
Stercobilin	Human fæces (1) and urine (2)	$C_{33}H_{46}O_6N_4$ (3)	496–498 [8 75 × 10^4] (4)	− 24 × 10^3 (5)
d-Urobilin	Human fæces (5) after antibiotic therapy and in biliary infection (6)	$C_{33}H_{40}O_6N_4$ (7)	499 [8 5 × 10^4] (4)	+ 29 × 10^3 (5)
Racemic *d*-urobilin	*d*-Urobilin by treatment with alkali (8)	$C_{33}H_{40}O_6N_4$ (assumed)	499 (4)	Inactive (8)
Urobilin-IXα	Probably human (9) fæces, synthesis (10) and *in vitro* dehydrogenation of mesobilirubinogen (11)	$C_{33}H_{42}O_6N_4$ (12)	496–497 (4)	Inactive
d-Urobilin IXα	Tetrahydro-*d*-urobilin by dehydrogenation (8)	$C_{33}H_{42}O_6N_4$ (assumed)	499 (4)	+ 29 × 10^3 (8)

* Figures in parentheses are reference numbers.

† Figures in square brackets are extinction coefficients

alkali at room temperature This difference between the two pigments may be explained by the effect of the extra unsaturation in facilitating the ionization of the hydrogen atom bound to the asymmetric carbon atom in *d*-urobilin Examples of simple optically active pyrrolidone compounds with one asymmetric carbon atom are 5-carboxypyrrolid-2-one (pyroglutamic acid) and its ethyl ester[14], which resemble the end rings of stercobilin without the β-substituents The possibility of optical contribution by other structural features in the urobilins is being explored

The large molecular rotations of the urobilinoid pigments[15,16] at the sodium *D*-line (589 mμ) are a consequence of the fact that their absorption bands (~ 500 mμ) are close to this line The availability of a spectropolarimeter[17] led us to measure optical rotatory dispersion curves for stercobilin and *d*-urobilin (Fig 2) from 620–470 mμ These curves show that the antipodal relationship of the rotations of these two pigments is more extensive than is evident from their effects solely on sodium light The typical 'Cotton effect' curves[18], with marked changes in optical rotation near the absorption maximum, show that the groups responsible for light absorption also affect rotation[19,20] The dipyrrylmethene group which is responsible for the main spectral absorption band of the urobilins[21,22] must also, therefore, be chiefly responsible for their optical activity at about 500 mμ Further work on other derivatives is in progress

It is interesting to note that in stercobilin the two centres of asymmetry adjacent to the dipyrrylmethene (DPM) groups are each attached to H, NH, CH$_2$—DPM, and a saturated alkyl group, here the amplitude[18] of the Cotton effect is moderate (~ 130 × 10^3) In *d*-urobilin, on the other hand, the centres of asymmetry are attached to H, N, CH$_2$—DPM and a conjugated, unsaturated system, the amplitude here is much greater (~ 300 × 10^3)

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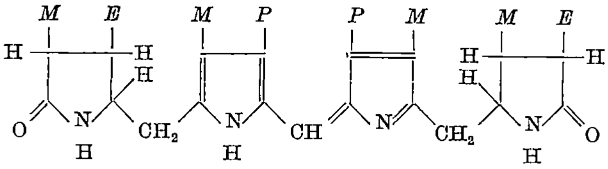
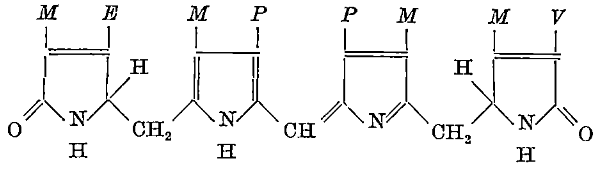


d-UROBILIN



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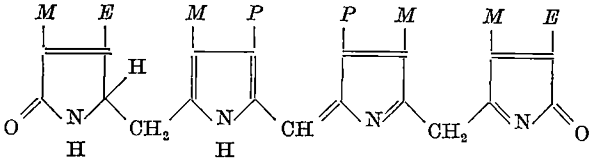

(or these structures with interchanged end-rings)

UROBILIN-IXα AND *d*-UROBILIN-IXα

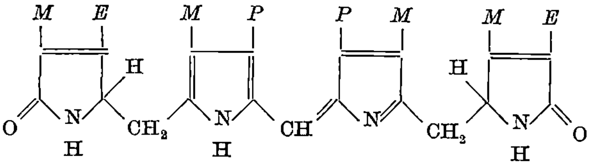

Fig 1 Key *M*, CH$_3$, *E*, CH$_2$CH$_3$, *P*, CH$_2$CH$_2$COOH, *V*, CH CH$_2$

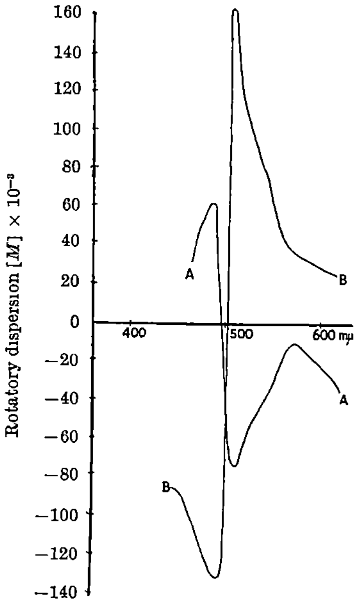

Fig 2 Rotatory dispersion curves, measured in chloroform solution, about 5 × 10^{-6} *M*, 1 dm tube, values are plotted as molecular rotations [*M*] = [α] × mol wt /100 Error for [*M*] about ± 5,000° *A*, stercobilin hydrochloride, *B*, *d*-urobilin hydrochloride

We are indebted to the following bodies for generous assistance in this work the Medical Research Council for a research grant (C H G and D C N), the Wellcome Trust, for the loan of the polarimeter, and the Department of Scientific and Industrial Research and the U S Army Research and Development Group, Frankfurt-am-Main, for grants (W K and P M J)

[1] Watson, C J, *Z Physiol Chem*, **204**, 57 (1956)
[2] Gray, C H, "The Bile Pigments", 127 (Methuen Monographs, London, 1953)
[3] Fischer, H, and Halbach, K, *Z Physiol Chem*, **238**, 59 (1935)
[4] Gray, C H, and Nicholson, D C (unpublished work)
[5] Lowry, P T, Zeigler, N R, and Watson, C J, "Recent Studies of the Urobilin Problem" Bull Univ of Minnesota Hosp and Med Foundation, No 7 (1952)
[6] Schwartz, S, and Watson, C J, *Proc Soc Exp Biol Med*, **49**, 641 (1942)
[7] Watson, C J, and Lowry, P T, *J Biol Chem*, **218**, 633 (1956)
[8] Gray, C H, and Nicholson, D C, *J Chem Soc*, 3085 (1958)
[9] Gray, C H, "The Bile Pigments", 112 (Methuen Monographs, London, 1953)
[10] Siedel, W, and Meier, E, *Z Physiol Chem*, **242**, 101 (1936)
[11] Watson, C J, *Z Physiol Chem*, **221**, 145 (1933)
[12] Watson, C J, *J Biol Chem*, **200**, 691 (1953)
[13] Birch, A J, *Chem and Indust*, 652 (1955)
[14] Karrer, P, and Kaase, W, *Helv Chim Acta*, **2**, 436 (1919) Froentjes, W, *Rec Trav Chim*, **62**, 97 (1943) Kibrick, A C, *J Biol Chem*, **174**, 845 (1948)
[15] Gray, C H, "The Bile Pigments", 117 (Methuen Monographs, London, 1953)
[16] Lowry, P T, Zeigler, N R, and Watson, C J, "Recent Studies of the Urobilin Problem", 175 Bull Univ of Minnesota Hosp and Med Foundation, No 7 (1952)
[17] Rudolf, H, *J Opt Soc Amer*, **45**, 50 (1955)
[18] For nomenclature, see Djerassi, C, and Klyne, W, *Proc Chem Soc*, 55 (1957)
[19] Heller, W "Physical Methods of Organic Chemistry", **2**, 880 (Weiseberger, Interscience, New York, 1956)
[20] Djerassi, C, Foltz, E W, and Lippman, A E, *J Amer Chem Soc*, **77**, 4354 (1955) and many subsequent papers
[21] Stern, A, and Pruckner, F, *Z Physik Chem.*, A, **182**, 117 (1938)
[22] Gray, C H, "The Bile Pigments", 34 (Methuen Monographs, London, 1953)

ADAPTATION OF A LEAD-TOLERANT POPULATION OF *AGROSTIS TENUIS* TO LOW SOIL FERTILITY

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ATTENTION has recently been directed[1] to populations within *Festuca ovina* and *Trifolium repens* adapted to different levels of soil calcium In the same publication the authors reported failure to find similar differentiation within *Agrostis tenuis* However, further work indicates that such differentiation does exist within this species

A population of *A tenuis* growing on lead-ore grindings at Gogınan (Cards) has already been shown to be tolerant of lead[2,3] However, in addition to being rich in lead the soil is of very low fertility Soil analysis by extracting with $N/2$ acetic acid gives the following values per 100 gm soil

Lead 7 1 m equiv , calcium 0 15 m equiv , phosphorus pentoxide 1 2 mgm

The growth of this population in relation to different mineral levels has therefore been investigated in sand culture, by a technique previously described[4] It was compared with a non-tolerant population from a nearby pasture The results of one such experiment are shown in Tables 1 and 2 This was designed as a factorial experiment with four levels of calcium and three of phosphate, but there was no significant interaction between the two nutrients

It is apparent that the pasture population responds to calcium and phosphate within these limits, whereas the lead mine population shows no response to calcium and a lesser response to phosphate However, in both cases the major part of the response is shown between the two lowest levels Therefore two further experiments were set up, the results of which are shown in Tables 3 and 4

Despite the rather erratic results for the lead mine population the general trends are the same as before The major response to calcium in the lead mine population occurs up to 4 p p m , whereas the pasture population increases in yield up to 10 p p m In the case of phosphate, the populations yield similarly at 2 and 4 p p m but diverge thereafter Calculation of linear regressions of yield on log nutrient concentration gives a good fit and high significance (0 01 per cent) for both nutrients in the case of the pasture population, but no significance and very poor fit for the lead mine population The differences between the two coefficients are not significant largely owing to the high error variance of the lead mine population This high variance may be explained if the population consists of a diverse collection of genotypes, the major unifying feature being the possession of lead tolerance Greater replication is desirable

Table 1 CALCIUM (DRY WEIGHT YIELD, GM)

Population	Calcium p p m			
	5	15	50	200
Lead mine	53 21	50 51	50 24	47 45
Pasture	53 42	77 65	70 43	58 94

S E = 7 75

Table 2 PHOSPHATE (DRY WEIGHT YIELD, GM)

Population	Phosphorus p p m		
	5	25	125
Lead mine	52 89	74 74	73 78
Pasture	66 80	93 22	100 42

S E = 9 02

Table 3 CALCIUM (DRY WEIGHT YIELD, GM)

Population	Calcium p p m				
	2	3	4	6	10
Lead mine	10 48	13 31	22 67	12 41	18 03
Pasture	13 35	15 79	16 01	19 52	27 91

S E = 3 90

Table 4 PHOSPHATE (DRY WEIGHT YIELD, GM)

Population	Phosphorus p p m				
	2	4	8	16	32
Lead mine	10 28	15 54	11 09	18 03	16 13
Pasture	10 99	16 66	21 87	20 99	26 87

S E = 3 70

The results indicate that the lead mine population is adapted to low levels of calcium and phosphate Walker *et al* [5] found similar adaptation in serpentine endemic species , but in their case high magnesium accompanied low calcium-levels The situation on lead mines is in many ways similar to that on serpentine, except that magnesium is not present in quantity However, here the differentiation is within a single species and not between species

Previous failure to find such differentiation within *A tenuis* may have been due to failure to find sufficiently severe habitats In more normal habitats *A tenuis* tends to be replaced by *A canina* at low fertility-levels, but in lead mine habitats this is not so As a result, *A tenuis* is here subject to the most extreme conditions of low fertility

A considerable range of adaptation to soil mineral-levels has now been found in this species It has populations tolerant of lead, copper and nickel poisoning, and of low levels of calcium and phosphate Either it is remarkable in this respect, or such variation is much commoner than previously reported The fact that both species previously examined in this Department showed similar variation suggests the latter to be the case

[1] Bradshaw, A D , and Snaydon, R W , *Nature*, **183**, 129 (1959)

[2] Bradshaw, A D , *Nature*, **169**, 1098 (1952)

[3] Jowett, D , *Nature*, **182**, 816 (1958)

[4] Bradshaw, A D , Lodge, R W , Jowett, D , and Chadwick, M J , *J Ecol* , **46**, 749 (1958)

[5] Walker, R B , Walker, H M , and Ashworth, P R., *Plant Physiol* , **30**, 214 (1955)

LETTERS TO THE EDITORS

PHYSICAL SCIENCES

Deposition of Trace Elements in Basic Magma

Perhaps the most detailed investigation of the fractionation of trace elements during the deposition of a mineral is that carried out on the basic magma of the Skaergaard intrusion[1]. We will consider the formation from the melt of the solid silicate phase of this magma, examining the inclusion of trace elements. The time sequence of the solidification is fairly well established[1]. Thus the deposition of the trace elements can be followed as a function of the percentage, X, of the solid phase formed. This is done in Figs. 1 and 2, where R gives the ratio of the concentration of the element in the liquid after X per cent solidification to the concentration in the initial liquid. A downward curvature to a line represents preferential removal of the element or a partition coefficient of that element favouring the solid rather than the liquid. The orders of deposition are

$Ni^{II} > Co^{II} > Fe^{II}$, $Ni^{II} > Cu^{II}$, and
$Cr^{III} > V^{III} > Sc^{III} > Ga^{III} > Fe^{III}$

I offer the following explanation of these orders.

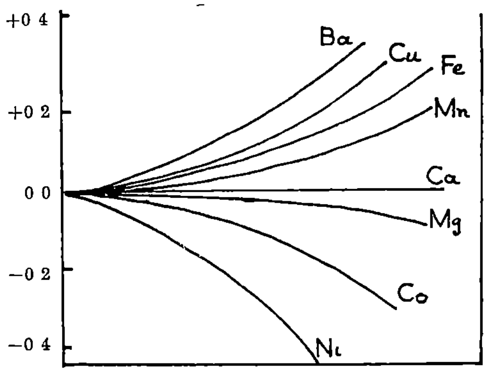

Fig. 1. The uptake of divalent cations into the silicate

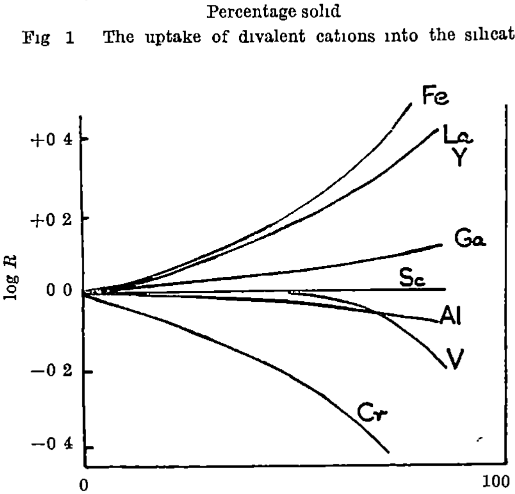

Fig. 2. The uptake of trivalent cations into the silicate

The process of the uptake of an ion into a crystal from a melt can be thought of as being characterized by (1) an increase in average co-ordination number to a fixed value for all the atoms, and (2) a decrease of the interatomic distances. The two terms are consistent with a greater bond energy, lower heat content, on formation of the solid phase. This is generally observed. The change in heat content can be further analysed. An element which is particularly stabilized in a given co-ordination site, say, in an octahedral hole, will be expected to gain greatly in stability on passing from a melt of irregular co-ordination number to a regular solid which provides such an octahedral hole. Again, ions which have large energies of polarization will gain in energy considerably on transfer from the liquid to the solid phase due to the shortening of interatomic distances. Polarization energies are very dependent upon these distances. Now it is well established that the polarization energies of d electrons are important in the stabilization of transition metal ions in certain symmetry positions, co-ordination spheres, rather than in others[2]. In an octahedral site these polarization energies are in the orders

$Ni^{II} > Co^{II} > Fe^{II} > Mn^{II} \gg Ca^{II}$, $Ni^{II} > Cu^{II} > Zn^{II}$
and $Cr^{III} > V^{III} > Sc^{III} = Ga^{III} = Fe^{III}$

These orders are almost exactly those found for the selective uptake of the ions into the Skaergaard intrusion silicates. The above ions normally go into octahedral holes in such minerals as these silicates. We conclude that selective uptake is based upon polarization energies which are highly dependent upon hole symmetry and interatomic distances. We expect that the same trace elements will be accumulated preferentially in silicates generally. This might explain the absence of nickel and chromium in biological systems. In minerals such as sulphides, the polarization will be different in origin and copper will be preferentially absorbed. In minerals providing holes of quite other symmetry, the order of uptake will be different again.

I wish to thank Prof. L. R. Wager, Prof. L. H. Ahrens and Dr. E. A. Vincent for their help.

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April 21

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[1] Wager and Mitchell, *Geochim. Cosmochim. Acta*, 1, 129 (1951).

[2] Orgel, *J. Chem. Soc.*, 4756 (1952).

Origin of the Worzel Deep-Sea Ash

In a recent paper[1], Worzel announced the discovery of an extensive ash deposit at the bottom of the Pacific Ocean. Ewing, Heezen and Ericson[2] have suggested in a companion paper that the deposit may well be of world-wide extent. If this should prove to be the case, the origin of the Worzel ash layer becomes a matter of extraordinary interest. The mass of a world-wide layer would be of the order of 1×10^{20} gm., which exceeds by a factor of ~ 300 the yield of the largest volcanic eruption recorded during historic times[3] (Tambora, 1815)

Moreover, the areal distribution of volcanic ash is usually quite limited[2]. Worzel and Ewing *et al.* have therefore proposed the following events as possible sources of the ash: a single very large volcanic explosion, the simultaneous explosion of many volcanoes, a cometary collision, or some other catastrophic event involving bodies of cosmic origin.

From the data of Öpik[3] one finds that a particle-size distribution peaking in the fractional mm. range, as observed for Worzel's ash, could indeed be obtained by ablation of mm.- to cm.-sized particles. However, a cometary or asteroidal origin of the ash is unlikely for a number of reasons. If the break-up were to occur at a distance from the Earth that was large compared with the distance to the Moon, only a very minute fraction of the debris would be swept up by the Earth, so that the mass of the disrupted body would have to be many orders of magnitude greater than 10^{20} gm., that is, far in excess of the masses of comets or asteroids. Moreover, the residence time of interplanetary debris is of the order of 10^6–10^9 years, as indicated by the cosmic-ray ages of meteorites[4,5], and Öpik's calculations[6], whereas the deposition of the Worzel ash took place within no more than a few years. Further, it is unlikely that a mass of the order of 10^{20} gm. can be accounted for even by means of a direct hit by a comet or asteroid. Although gravitational tests have only yielded an upper limit of $\sim 10^{24}$ gm. on the masses of comets, several other independent arguments indicate that the mass of a reasonably large comet (Halley's comet) is about 3×10^{19} gm. The masses of the more typical comets are probably significantly lower than this. Asteroids of the required mass do exist but are unlikely to be found so far outside the asteroidal belt. Finally, although its chemical composition has not yet been determined, the ash is quite unlike meteoritic[2], cometary, or asteroidal matter, as indicated by its low density and refractive index (2.38 and 1.500, respectively), its low nickel content ($\leqslant 0.01$ per cent.; spectrochemical analysis by Dr. A. Du Fresne), and its glassy character. These properties are much more reminiscent of terrestrial crustal material (for example, volcanic ash), which is high in silicon, calcium, aluminium, sodium and potassium, and low in magnesium, iron and nickel relative to undifferentiated meteoritic matter. The resemblance to volcanic ash has been pointed out by Ewing *et al.*[2]

Two other cosmic sources might be considered: galactic dust clouds and the Moon. A simple calculation shows that passage through a galactic dust cloud of some two solar masses would enable the Earth to pick up a 10-cm. layer of non-volatile matter. However, if the pick-up is to be complete within a short time, say 10 years, the cloud must have had the unreasonably high density of 10^{-11} gm./cm.^{3}. The only known, non-stellar objects in space that may have densities of the right order of magnitude are the so-called 'globules' (believed by some to be proto-stars in an early stage of gravitational contraction). The probability of encountering such an object is exceedingly small; moreover, any reasonable distribution of particle sizes within the globule would contain enough grains in the range of maximum light absorption (that is, $\sim 0.5\mu$) to black out completely the Sun, with calamitous effects on terrestrial life. Finally, the near-passage of a massive cloud would perturb the planets, destroying the regularity of their orbits, and would almost certainly sweep the comets from the solar system.

A catastrophic event within the Earth–Moon system, for example the collision of a giant meteorite with the Moon, cannot be ruled out on grounds of chemical composition. The composition of the Moon's crust is not known; but in the light of recent work on mineral differentiation in small bodies[7], there is no *a priori* reason why it should not be differentiated to a degree close to that of the Earth's crust or Worzel's ash. However, it can be shown that a meteoritic impact of the kind that gave rise to the lunar craters cannot eject enough material to account for the collection of 10^{20} gm. by the Earth. The mass deficit of the very largest craters may barely approach this value, but even under the most favourable conditions scarcely more than a few per cent of the ejected matter will reach the Earth within the required few years.

It appears that an extra-terrestrial origin of Worzel's ash is highly improbable. Yet its world-wide distribution, if demonstrated to be true, will be difficult to explain even in terms of a terrestrial origin. Data on the dispersal of H-bomb debris and volcanic ash indicate that the distribution of particles in the 70–200μ range is limited to distances of the order of 10^3 km. or less. It will be of interest to establish its origin in a single event by chemical analysis of samples from widely scattered locations.

A volcanic eruption of this magnitude should have at least two other observable effects. It would carry enough μ-sized dust particles into the stratosphere to reduce the amount of sunlight reaching the Earth, possibly enough to initiate a period of glaciation. This possibility has been independently suggested by Dr. Bruce C. Heezen (private communication). A palæotemperature measurement of material immediately above and below the Worzel layer may provide a clue in this respect. Furthermore, the mass deficit at the eruption site would produce a negative gravity anomaly that may not yet have been completely obliterated by isostatic equilibrium.

This work was supported in part by the U.S. Atomic Energy Commission.

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[1] Worzel, J. L., *Proc. U.S. Nat. Acad. Sci.*, **45**, 349 (1959).

[2] Ewing, M., Heezen, B. C., and Ericson, D. B., *Proc. U.S. Nat. Acad. Sci.*, **45**, 355 (1959).

[3] Öpik, E., "Physics of Meteor Flight in the Atmosphere" (Interscience, 1958).

[4] Reed, G. W., and Turkevich, A., *Nature*, **180**, 594 (1957).

[5] Fireman, E. L., and Schwarzer, D., *Geochim. et Cosmochim. Acta*, **11**, 252 (1957).

[6] Öpik, E., *Proc. Roy. Irish Acad.*, A, **54**, 165 (1951).

[7] Fish, R. A., Goles, G. G., and Anders, E. (unpublished work).

Wear Observations through Interfacial Micro-Windows

DIRECT observations of wearing processes are generally obscured completely by the slider or bearing material. As a result, a good deal of speculation has accumulated concerning the unknown mechanisms of wear. With reference to graphite, no satisfactory understanding had been gained.

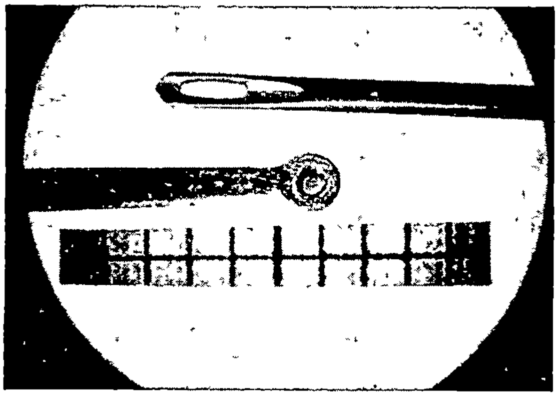

Fig. 1. Diamond micro-window in mounting, with fine needle and metric strip (× 6)

In a recent micrographic study of wear[1] upon graphite it was shown that the wearing process could be studied more directly by arranging a sliding contact under a microscope and following the detailed processes. The observations were further simplified by using single oriented crystals for the surfaces undergoing the wear. With selected adjustments of the illumination a good deal of new information was revealed.

An obstacle in this micrographic technique was that the slider or micro-probe was opaque and hid the contact site from view. Only surrounding effects were visible. In continuation it was found that the slider may be a thin transparent body which then serves as a micro-window. Then the real interface of the contact may be focused upon directly at high magnification.

Small glass lenses as sliders were first tried. A plano-convex lens was mounted at the end of a needle in a micro-manipulator and was pressed against graphite or molybdenite crystals having flat areas. The well-known Newton's interference fringes which were produced over the small air gaps indicated at once the topography of the surfaces, in respect to elevations and actual zone of contact.

Upon sliding the glass over a crystal surface, the details of the wearing process were directly observed, including the variations of contact position, the influence of single asperities and of particles on the friction and wear, the geometrical nature of the wear removal process, and the surface adhesion.

As a further step, a diamond micro-window has been machined for this study. This provides a hard transparent carbon tool of known geometry to slide against a plane graphitic carbon surface. This diamond lies completely within the field of view at magnification of 320, and hence all contact areas may be seen at once. It is smaller than a fine needle's eye (Fig. 1) with a maximum diameter of 0.94 mm and thickness of 0.66 mm. It is optically flat on the upper surface, facing the microscope objective, and slightly convex on the sliding surface, but optically smooth. As a sliding window, it shows a detailed picture of surface interactions upon its face during sliding, as well as the topography from the Fizeau fringe patterns.

The technique described makes it possible to view surfaces as they are brought into contact at magnifications large enough to yield significant results, to observe the subsequent damage to the sliding surfaces as it occurs, and to measure the contributions of individual asperities to the friction.

I wish to thank E. H. Hull and O. Brusdal, of this Laboratory, who made suggestions concerning the geometry of the diamond and also machined and mounted it.

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May 18.

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[1] Savage, R. H., *Nature*, **183**, 315, 454 (1959).

Rapid Estimation of the Specific Surface of a Powder

The rapid estimation of the specific surface of a powder falling in the sub-sieve size-range is a matter of considerable industrial importance; but the techniques available for this purpose are limited in number.

One of these rapid techniques is that which may best be described as the 'single observation photo-extinction method'. Owing, however, to the omission of an important variable, this test gives results which are subject to very considerable error, and it is the object of this communication to direct attention to an empirical correction which, while retaining all the advantages of the simple test, leads to results which have adequate accuracy for many industrial purposes.

In the 'single observation' test a known weight of the powder under analysis, suspended in a known volume of a suitable fluid, in an optical cell, is maintained in turbulent motion by means of a stirrer. A beam of light is projected across the cell and by means of a photo-cell, or similar device, the intensities of the incident and emergent beams are measured.

The 'specific surface' of the material is then calculated by use of the equation

$$S_m = \frac{4}{Cl} \log_e \frac{I_0}{I} \qquad (1)$$

where S_m is the measured 'specific surface' in cm.^{2}/gm., C is the concentration of the suspension in gm./cm.^{3}, l is the length, in cm., of the light path through the suspension and I_0 and I are the intensities of, respectively, the incident and emergent beams.

This expression is, however, not strictly accurate since it is based upon the assumption that, for a small particle, the light energy absorbed and scattered outside the small solid angle subtended by the photo-sensitive surface at the centre of the particle is directly proportioned to the cross-sectional area of the particle, whereas in fact this is not so.

It has been suggested by one of us[1] that for an industrial powder having a wide range of particle size an empirical correction for this variation of the extinction coefficient with particle size can be made by the use of the expressions

$$\begin{array}{rclrcl} 200 < & S_m & < 20{,}000 & S_b & = & 3.3\, S_m^{0.77} \\ & S_m & = 20{,}000 & S_b & = & 8{,}000 \\ 20{,}000 < & S_m & < 70{,}000 & S_b & = & 66\, S_m^{0.5} \end{array} \qquad (2)$$

where S_m is calculated from equation (1) and S_b is a better approximation to the true value.

In the derivation of these expressions it has been assumed that the density of the powder under test is approximately 3.5 gm./cm.^{3} and, furthermore, in the original publication the suggestion was supported by a very small amount of experimental evidence.

Recent reconsideration of the problem shows, however, that improved accuracy over a wider range of

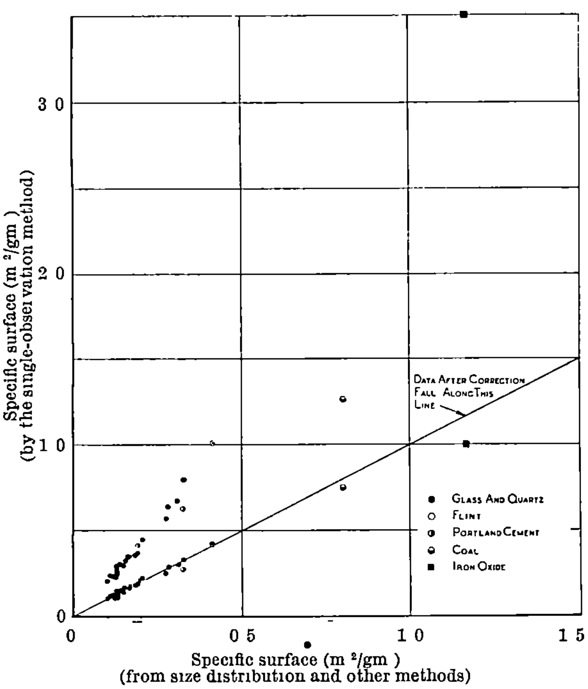

Fig 1

particle density can be obtained by the use of the modified equations

$$\begin{aligned} \frac{600}{\rho} < S_m < \frac{60,000}{\rho} \qquad & S_b = 4.5\rho^{-0.25}S_m^{0.77} \\ \frac{60,000}{\rho} < S_m < \frac{180,000}{\rho} \qquad & S_b = 120\rho^{-0.5}S_m^{0.5} \end{aligned} \tag{3}$$

During a recent research the specific surfaces of a number of samples of quartz and glass mill products have been determined from the size distribution curves (determined by photo-extinction methods) and by the single-observation test These results, together with those relating to a number of other materials, for which the specific surfaces have been determined by a variety of methods, are shown in Fig 1

In this figure are also shown these results after 'correction' by use of equations (3), and it is seen that these results, although suffering scatter, are in reasonable accord with the results deduced by other methods

Thus, it is considered that this method together with the above equations provides a rapid means for the estimation of the 'specific surface' or 'mean' particle-size of a powder, with an accuracy sufficient for many industrial purposes

Attention should, however, be directed to the following restrictions (1) The method is empirical and so should be applied with care (2) The correction equations are strictly applicable only to results obtained upon apparatus having approximately the same geometry as has the apparatus used for the original tests This geometry has been described elsewhere[1] (3) The correction equations are deduced for materials having a fairly wide range of size, for example fine mill products, and are not applicable to materials which have been artificially separated into very narrow size ranges (4) For values of S_m in the neighbourhood of $60,000/\rho$, there will, due to the complex behaviour of the extinction coefficient–particle size in this region, be considerable scatter, but even so the 'corrected' values, S_b, will be more nearly correct than will be the values of S_m

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[1] Rose, H E , *J App Chem* , **2**, 217 (1952), "The Measurement of Particle Size in Fine Powders" (Constable and Co , Ltd , London)

Effect of Temperature on the Rate of Setting of Gypsum Plaster

Experiments carried out in this laboratory with some commercial gypsum plasters show that, between 0° and 50° C , temperature may exert a comparatively small effect upon the rate of hydration of the calcium sulphate hemihydrate In most cases, the induction period (defined as the time for the rate of increase of temperature to exceed 0 1° C per min) of mixtures of plaster and water contained in a Dewar flask is constant from 0° to 40° C , and the maximum rate of increase of temperature reaches a feeble maximum at about 25° C [1], although there are minor but distinct deviations from this pattern (see, for example, Fig 3) Similar results have been found by Householder[2]

The effect of temperature on the rate of setting of a number of dental plasters has been subjected to a careful study by Worner[3], who found that the rate was roughly constant between 20° and 60° C but, unlike my results, dropped sharply below 20° C or a few degrees lower His plasters also showed minor variations in behaviour The parameters (induction period and maximum rate of increase of temperature) that I have used are measures of the rate of hydration of the hemihydrate, whereas Worner used the Gillmore test, which gives a measure of the stiffness of the mixture of plaster and water Recent work[4,5] strongly supports the view that the dominant process in the thickening of mixtures of plaster and water is the formation of an interlocking network of crystals of calcium sulphate dihydrate, although some previous authors have supported a colloidal mechanism[6,7] It is then of interest to know whether or not the Gillmore test yields results which run parallel with the kinetic parameters of the reaction, and whether the sharp increase in setting time observed by Worner as the temperature falls below 15° C was a characteristic of his materials only I have consequently carried out Gillmore tests[8] on plasters, for which the induction periods and maximum rates were also determined

Figs 1–3 show the times for completion of the Gillmore initial and final sets, induction periods and maximum rates plotted against temperature for three plasters with different characteristics In making the Gillmore tests the samples were covered with paraffin oil to prevent surface drying (cf Worner[3]) With plasters *A* and *B* the maximum rate rises to a feeble maximum at about 25° C and the induction periods are roughly constant between 0° and 40° C Three other plasters studied in detail show the same behaviour Plaster *C* is unusual in that the induction period decreases below 10° C and the maximum rate is constant from 5° C to 30° C The initial set is complete about 15 min after the end of the induction period, and when variations in the maximum rate are taken into account it is seen that the Gillmore initial set does move parallel with the kinetic parameters of the hydration of the hemihydrate This confirms the view that the dominant process in setting is the formation of crystals of calcium sulphate dihydrate, as work reported elsewhere suggests that the end of the induction period marks the formation of a certain surface area of crystals of dihydrate[9].

Plaster *A* shows an increase in the time for the completion of initial set below 30° C. but not the sharp effect shown by Worner's plasters. I have used retarder-free building plasters which had been stored in air-tight containers until they gave steady results and were generally very much slower in setting than Worner's plasters. Work reported in part elsewhere[9] suggests that the rate of hydration of calcium sulphate hemihydrate in plaster pastes is determined by the density of nuclei for the crystallization of the dihydrate, the effective surface area of the dihydrate present at the beginning of the reaction, and the rate of supply of calcium and sulphate ions to the surface of the growing phase. Reduction of temperature will tend to reduce the rates of dissolution of the hemihydrate and diffusion of calcium and sulphate ions, and I have already shown that in a number of plasters the density of effective nuclei increases as the temperature is lowered[1]. Another factor is the increase in solubility of the hemihydrate as the temperature is lowered. Whether the rate of hydration rises or falls as the temperature is lowered depends upon which of these effects predominates. The high rates for the plasters used by Worner suggest that they were heavily seeded with nuclei. If these were mostly greater in size than the critical nucleus it is possible that the density of effective nuclei did not increase relatively as greatly as in the cases I have studied, so that the time for completion of the initial set would increase more markedly as the temperature was lowered. It is noteworthy that the effect is relatively more marked in the most reactive plasters quoted by Worner. However, the magnitude of the effects observed by Worner at low temperature appears too large to be compatible with the assumptions upon which my theory is based[9].

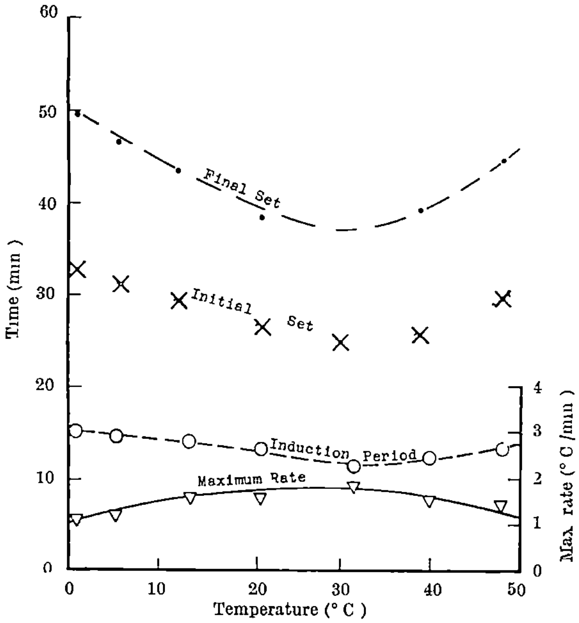

Fig. 1. Times for completion of initial and final set (average of four measurements), induction period and maximum rate of increase in temperature plotted against initial temperature for 100 gm. plaster *A* and 60 ml. water

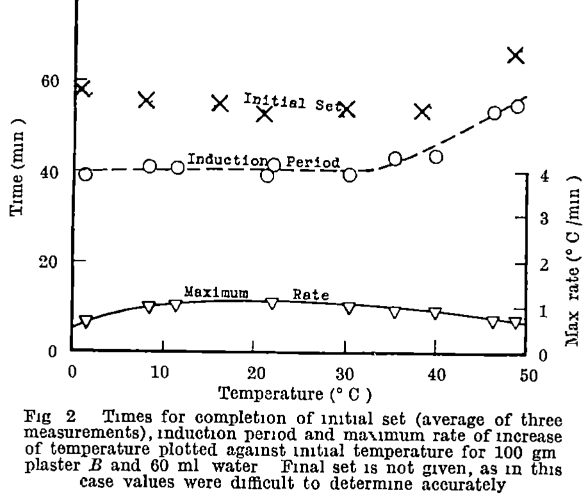

Fig. 2. Times for completion of initial set (average of three measurements), induction period and maximum rate of increase of temperature plotted against initial temperature for 100 gm. plaster *B* and 60 ml. water. Final set is not given, as in this case values were difficult to determine accurately

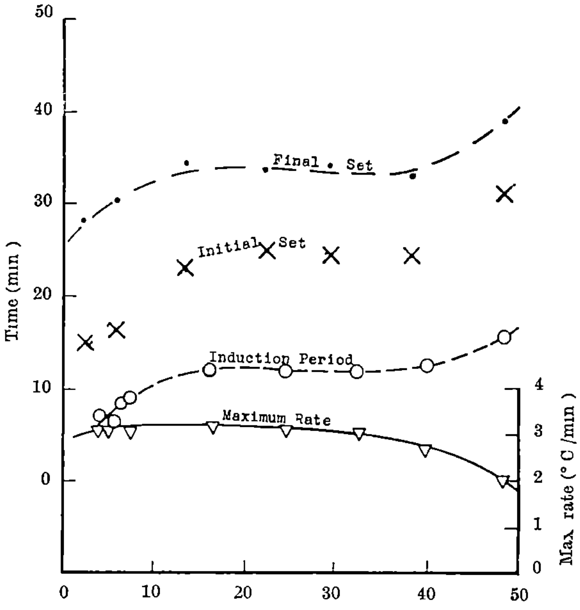

Fig. 3. Times for completion of initial and final set (average of two measurements), induction period and maximum rate plotted against initial temperature for 100 gm. plaster *C* and 60 ml. water

This investigation forms part of the programme of work carried out within the Division of Building Research and sponsored by the Associated Fibrous Plaster Manufacturers of Australia.

I wish to thank Mr. A. R. Docking, director of the Commonwealth Bureau of Dental Standards, for the loan of the Gillmore apparatus, and Mr. K. I. Lardner of this Division for assistance with the experimental work.

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[1] Ridge, M. J., *Nature*, 182, 1224 (1958).
[2] Householder, F., *J. Amer. Ceram. Soc.*, 1, 578 (1918).
[3] Worner, H. K., *J. Dental Res.*, 23, 305 (1944).
[4] Powell, D. A., *Aust. J. App. Sci.*, 9, 24 (1958).
[5] Ridge, M. J., *Aust. J. App. Sci.*, 9, 163 (1958).
[6] Fischer, H. C., *Amer. Soc. Test. Mat. Bull.*, No. 192, 43 (1953).
[7] Ostwald, W., and Wolski, P., *Kolloidzschr.*, 27, 78 (1920).
[8] Australian Standard Specification No. *T* 4-1951, 8 (1951).
[9] Ridge, M. J., *Aust. J. App. Sci.*, 10, 218 (1959).

Forces between Titanium Dioxide Pigment Particles

Electron microscope techniques have been used for obtaining information on the nature of the aggregation process occurring between particles of titanium dioxide pigment in the dry state.

A cloud of air-dispersed rutile titanium dioxide pigment was formed by passing air from a high-pressure jet through a flask containing the dry pigment. The degree of dispersion in this cloud was assessed by collecting a specimen on a 'Formvar'-coated electron microscope specimen grid (Fig. 1). To examine the aggregation properties of the pigment, an electron microscope grid, without a specimen supporting film, was held in the pigment cloud for periods of 1 min. After each period, electron micrographs were taken of a selected area of the grid. Fig. 2 shows 'chains' of pigment particles adhering to the copper grid; with further exposures to the pigment cloud, a network of pigment particles was gradually built up (Figs. 3 and 4). Stereo-micrographs have indicated the three-dimensional nature of this structure.

An enlarged portion of a typical pigment network (Fig. 5) illustrates the high proportion of contacts in the direction of the *c* axis of the crystal, at the pyramidal faces.

From the maximum lengths of chains supported at only one contact, the force of adhesion between two particles was calculated as $\gg 6 \times 10^{-7}$ dynes.

Possible forces causing the aggregation are:

(*a*) *Van der Waals—London forces.* For two spherical particles of equal radius, the attractive force is defined by the relation

$$V = -A/6\ \{2/(S^2-4) + 2/S^2 + \log_{10}[(S^2-4)/S^2]\}$$

where V is the energy of interaction between the two spheres; A is a constant $\sim 10^{-12}$ ergs; $S = R/a$; R is the separation between the centres of the spheres; a is the radius of the two spheres[1]. For two pigment particles with equivalent spherical radii of $0{\cdot}2\mu$ and a separation of $0{\cdot}005\mu$ between surfaces (the approximate limit of resolution of the available electron microscope) the attractive force is $\sim 7 \times 10^{-6}$ dynes.

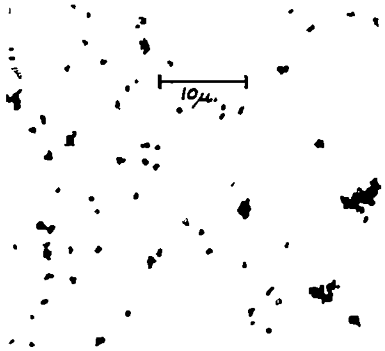

Fig. 1

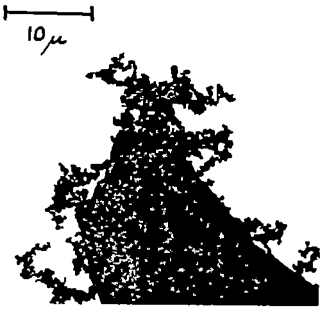

Fig. 2

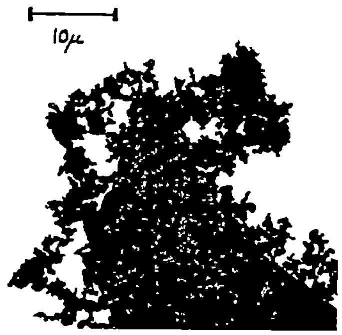

Fig. 3

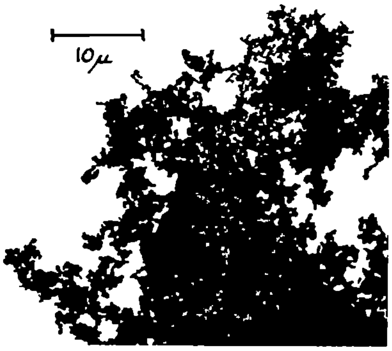

Fig. 4

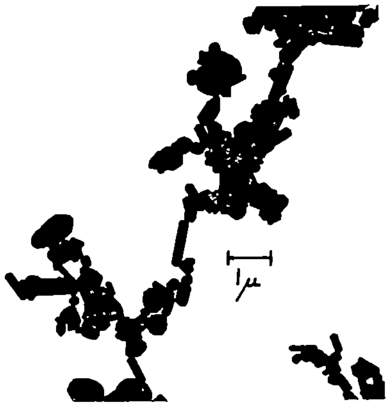

Fig. 5

(*b*) *Induced electrostatic forces.* A particle which has previously been charged by frictional processes in the original dispersion can induce an electrical polarization in an uncharged particle passing within its field. This polarized particle would then be attracted to the original particle and be available for the polarization of other particles in the pigment cloud. The force between two unit electronic charges at a separation of $0{\cdot}005\mu$ is of the order of 1×10^{-6} dynes, a value consistent with the attractive force calculated from the electron micrograph.

Work on the semi-conducting nature of titanium dioxide supports this hypothesis. It has been observed that high temperatures enhance the aggregation in dry pigments. High temperatures also lead to an increased electronic mobility in titanium dioxide[2] A similar phenomenon has been observed with dry quartz sand[3] The electronic conductivity of rutile titanium dioxide below 300° C is at a maximum along the c axis of the crystal[2], this is consistent with the orientation of the particles in Fig 5 On the evidence available at present, we prefer this mechanism to that described in section (a)

Acknowledgments are made to the Directors of Laporte Titanium, Limited, for permission to publish this communication

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[1] Verwey and Overbeek, "Theory of Stability of Lyophobic Colloids" (Amsterdam, 1948)

[2] Cronemever, *Phys Rev*, **87**, 876 (1952)

[3] Rinde, M Sc thesis, University of California (1926) Loeb, "Static Electrification", 200 (1958)

Temperature Variation of the Principal Magnetic Moments of Co^{++} Ions and the Asymmetry of the Crystalline Electric Field in Cobalt Acetate Tetrahydrate

The ground-state of the free divalent cobalt ion is $3d^7$, $^4F_{9/2}$, and the potential due to the crystalline electric field in the neighbourhood of the six co-ordinated cobalt ion conforms to

$$V = D(x^4 + y^4 + z^4) + Ax^2 + By^2 - (A + B)z^2$$

the fourth-order terms in the expression represent the cubic, and the quadratic terms the rhombic, part of the field The observed magnetic properties can then be explained on the assumption that the field is predominantly cubic in symmetry with a feeble rhombic component superposed If the field is due to an octahedral distribution of water molecules around the Co^{++} ion, the seven-fold orbital degeneracy is split into two triplets and a singlet, and the sign of the cubic field coefficient is such as to make one of the triplets the ground-state, the separation of which from the other triplet is of the order of 10^4 cm $^{-1}$ With such a disposition of the orbital Stark pattern, the components of the lower triplet being further separated to the extent comparable to kT by the rhombic part of the field, and the spin-degeneracy slightly raised through the spin-orbit coupling, the calculations of the principal magnetic moments naturally become very complicated Schlapp and Penney[1] have, however, made detailed theoretical calculations of the principal magnetic moments of cobalt salts Assuming the cubic field to be always of the same intensity, and one of the rhombic field constants zero, they assign different values to the other, namely, $A = 0$, 40, 200, etc With a small rhombic field the effective magnetic moments naturally become different, but they decrease in more or less the same way as with a purely cubic field when the temperature is lowered The principal moments separate out further when A is 200, and with the fall of temperature the moment having the largest value increases, reaches a maximum and then falls, while the other moments decrease From the experimental magnetic data on cobalt salts[2] it seems that the rhombic field in them is not so strong as to produce a rise in the maximum magnetic moment referred to above

In the Tutton salts the field is determined almost wholly by the octahedron of water molecules immediately surrounding the ion, and hence the deviation from the cubic symmetry will be small If, on the other hand, the members of co-ordination of the cobalt ion be not all alike, then there will be a possibility of the rhombic field becoming stronger It seems that cobalt acetate tetrahydrate is a case in point as revealed from its fine structure studies by X-rays[3] The space group is $P2_1/c$, and the unit cell contains two molecules Each cobalt ion is surrounded octahedrally by four water molecules and two oxygens of acetate groups The cobalt–water (2 11 and 2 06 A) and the cobalt–oxygen (2 12 A) distances suggest that as in nickel salts, the moment in the plane containing the Co^{++} ion and the oxygens of water molecules and of acetate groups is greater than in the direction normal to it

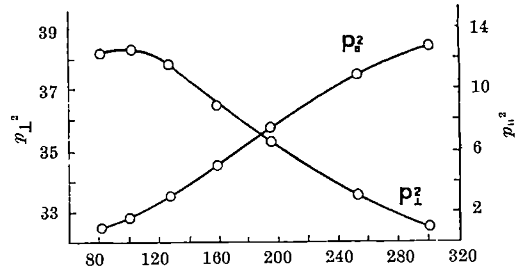

Fig 1 Variation of magnetic moments with temperature for cobalt acetate

The room temperature measurements[4] show that the magnetic anisotropy of cobalt acetate is highest of all the cobalt salts studied so far, and it clearly indicates a strong non-cubic field We have, therefore, measured the temperature variation of the principal magnetic susceptibilities of the crystal down to liquid air temperature The results are shown graphically in Fig 1 The trend of the magnetic moment versus temperature curves supports the existence of a strong rhombic field around the Co^{++} ion in $Co(CH_3COO)_2 4H_2O$

The work will be reported upon more fully elsewhere

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[1] Schlapp, R , and Penney, W G , *Phys Rev*, **42**, 666 (1932)

[2] Jackson, L C , *Phil Trans Roy Soc*, **224**, 1 (1924) Bartlett, B W , *Phys Rev*, **41**, 818 (1932) Bose, A , *Ind J Phys*, **22**, 276 (1948) Guha, B C , *Proc Roy Soc* A, **206**, 353 (1951)

[3] Niekerk, J N van, and Schoening, F R L , *Acta Cryst*, **6**, 609 (1953)

[4] Mookherji, A , *Ind J Phys*, **20**, 9 (1946)

Visible Absorption Spectra of Copper-ethylene-diamine-*bis*(acetylacetone) in the Crystalline State

For square planar copper complexes the crystal field theory predicts a splitting of the five-fold degenerate d-orbital energy-levels into four energetically different levels, d_{xy}, d_{z^2}, $d_{x^2-y^2}$ and $d_{zx}(d_{yz})$, in the order of diminishing energy[1] The visible absorption in these systems is associated with the transitions from d_{zx} (d_{zy}) to d_{xy} (w_1), from $d_{x^2-y^2}$ to d_{xy} (w_2), and from d_{z^2} to d_{xy} (w_3), where w_1 is the shortest wave-length and w_3 the longest wave-length band with w_2 in between The absorption spectra of square planar copper complexes in solution invariably consist of one broad absorption band in the visible region, which, however, could be resolved into three component bands by Gaussian analysis[2] With the object of finding if these split levels could be detected in the absorption spectra of the single crystal of a square planar copper complex, the present investigation was undertaken on the absorption spectra of an elongated platelet of copper-ethylene-diamine-*bis*(acetylacetone)

The optical part of the experimental equipment consisted of a single filament tungsten lamp, Hilger glass prism monochromator and a Leitz polarizing microscope The electrical part consisted of a 1*P*21 photomultiplier tube, a high-voltage stabilized power-supply unit and a stabilized d c -voltage amplifier The crystal was placed on the stage over a glass slide, and was brought to focus visually The eye was then replaced by the phototube assembly The objective – eye-piece combination used was such that the crystal completely covered the field in any orientation The orientation of the plane of polarization of the incident beam with respect to the long axis of the crystal could be varied either by rotating the polarizer or by rotating the stage with the crystal

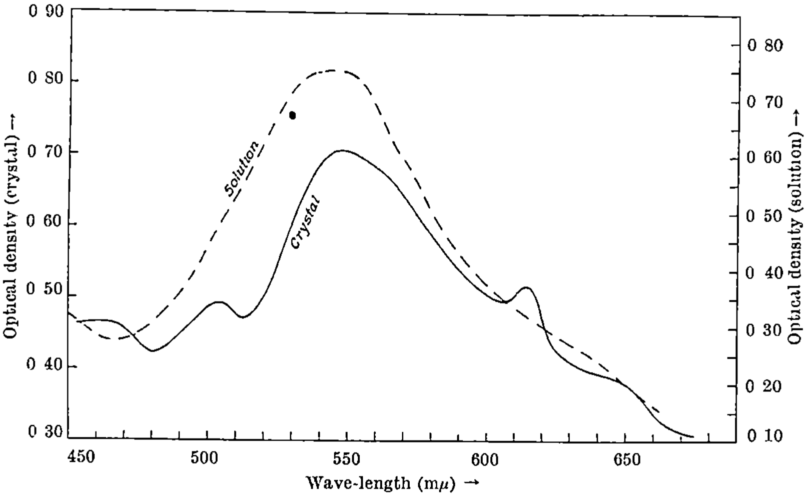

Fig 1

In Fig 1 the full-line curve represents the absorption spectrum of the crystal with the incident light polarized along the long axis of the crystal The curve shows three peaks at 505 mμ, 545 mμ and 615 mμ respectively The dotted curve represents the absorption spectrum of the same chelate in alcoholic solution It is evident that the spectrum in solution consists of one broad band with no fine structure By Gaussian analysis the solution band may be resolved into three bands with peaks at 510 mμ, 545 mμ and 600 mμ, which correspond fairly well with the three peaks observed in the spectrum of the crystal

With the incident light unpolarized or polarized at right angles to the long axis of the crystal, the absorption spectra were almost identical with those given in Fig 1, apart from a slight loss in the fine structure

Thanks are due to M/S Emission Radio and Varieties, Calcutta, for their kind help in constructing the electrical part of the measuring instrument

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[1] Belford, Martell and Calvin, *J Inorg Nucl Chem* , 2, 11 (1956)
[2] Jorgensen, *Acta Chem Scand* , 8, 1495 (1954)

Possible Asymmetry in the Daily Range of the Geomagnetic Vertical Intensity around the Magnetic Equator

IN a recent paper, I have suggested that if the indication of an asymmetry in the daily range of the geomagnetic vertical intensity (Z) on opposite sides of the magnetic equator (higher ranges to the south) is confirmed, it might be explained by the opposition in phase of the equatorial electrojet effect on Z and the normal Z-variation on one side and the agreement of their phases on the other[1]

Magnetograms have now been obtained from Zaria, a new magnetic observatory in Nigeria on the northern side of the magnetic equator and about the same distance from that equator as Ibadan is south of it Zaria is thus near the latitude on the northern side at which the effect of the electrojet on Z-variation should be greatest, as Ibadan is supposed to be near the latitude of maximum to the south An examination of Z-variation at Zaria shows that the daily ranges of Z are as high as at Ibadan and the two Indian stations to the south of the magnetic equator occupied by Pramanik and Yegnanarayanan[2] Therefore, Zaria does not confirm the asymmetry It may still be necessary to record variations of the vertical force at a number of other stations on both sides of the equator before a definite statement can be made on the existence or otherwise of an asymmetry

Even if the asymmetry is confirmed, it is not likely to be explained by the phase relationship as simply as put in my paper[1] In the first place the consideration leading to the statement involved an error in reversing the direction of the Z-effect of the jet current during day-time Secondly, the true position is not so simple because the phase relation at places close to the geographical equator would change as the S_q-current system moves northwards or southwards according to season The situation is further complicated by possible movements of the electrojet itself according to season It is considered that further investigation should wait until it is known whether and how the electrojet moves according to season

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[1] Onwumechilli, C A , *J Atmosph Terr Phys* , 13, 235 (1959)
[2] Pramanik and Yegnanarayanan, *Ind J Met Geophys* , 4, 353 (1952)

ASTRONOMY

Prediction of Sunspot Numbers until the End of the Present Cycle

SINCE November 1956 the use of a most elementary long-term prediction method[1] for sunspot numbers has been pursued with surprising success C N Anderson[2] directed attention to the possible existence of a 169 years period in solar activity The coincidence

Table 1

	1957		1958		1959	1960	1961	1962	1963	1964	1965	1966	1967
	p	*o*	*p*	*o*									
January	172	170	196	198	164	137	93	81	62	46	29	15	0
February	175	172	189	199	163	136	91	80	61	49	28	14	0
March	182	177	187	203	168	129	89	79	59	50	23	11	0
April	185	183	180	198	165	122	87	78	58	47	19	11	0
May	184	187	179	191	167	117	86	77	57	46	19	9	0
June	188	189	178	189	163	111	86	76	55	43	16	6	0
July	191	191	176	187	160	108	87	75	51	40	19	5	0
August	189	190	177	182	157	106	85	73	52	41	19	2	0
September	191	194	178	183	153	103	83	71	50	36	16	1	0
October	196	194	174	181	147	100	81	70	49	33	17	1	0
November	197	197	169	—	143	97	80	68	48	31	16	0	0
December	197	197	167	—	140	95	82	64	46	28	15	0	0

of values between the two periods 1749–85 and 1918–54 is most striking

This fact has been used in our service for ionospheric predictions almost from the beginning of the present cycle, but with the increase in activity marked differences appeared It was realized, however, that a good fit could be obtained by multiplying figures observed 169 years before by a factor of proportion Using running means over 13 months and taking July 1784 as a starting date, linked to April 1954, the following equation was obtained in November 1956

$$\bar{x} = 1\;488\,\bar{y} - 12\;5 \qquad (1)$$

where $\bar{y}$ is the value for a particular month of the old cycle and $\bar{x}$ the corresponding value for the present cycle

In Table 1 predicted sunspot numbers (*p*), calculated in November 1956 with the above formula, are given for 1957 and 1958 and compared with the available Zurich observational values (*o*)

The mean square root of deviation between observed and predicted values is 1 6 sunspot, which is very small indeed

Using the data of April 1954–October 1958, a new equation has been derived for a still better fit

$$\bar{x} = 1\;527\,\bar{y} - 13\;4 \qquad (2)$$

Although the change between equation (1) and (2) is very small, this last has been used for the prediction of sunspots as listed in Table 1 from 1959 until the end of the cycle in January 1968 From November 1966 the formula gives negative values, these have been replaced by zeros

Owing to the very empirical way in which these figures have been derived it is essential to keep a close check with observations as they appear

However good the relationship between the old and the new cycle has been for the past five years, it does not mean, unfortunately, that it will remain so with certainty in the future

Without theoretical support, nothing better can be expected for such long-term prediction

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[1] Herrinck, P, *Bull Acad Roy Sci Col*, Nouvelle série, 4 (6) 1274 (1958)

[2] Anderson, C N, *J Geophys Res*, 59, No 4 (1954)

Anomalous Continuum Radiation from Jupiter

FOLLOWING the report of Dr Frank D Drake[1], of the National Radio Astronomy Observatory, that Jupiter emits anomalously large amounts of continuum radiation in the vicinity of 21-cm wavelength, observations of Jupiter were undertaken with the Harvard 60-ft radio telescope With the instrument used as a direct radiometer with a bandwidth of 2 Mc /sec in the vicinity of 1,420 Mc /sec, a signal of amplitude several times the noise fluctuation was found in the expected position of Jupiter on most traces. The averages of at least five right-ascension drift curves were used to obtain the antenna temperatures given in Table 1 The probable error is less than 0 15° K

Table 1

Time (U T)	Date	No of curves averaged	T_a (° K)
0203–0403	May 16, 1959	5	0 51
0408–0608	,, 16 ,,	5	0 73
0613–0817	,, 16 ,,	5	0 46
0451–0711	,, 18 ,,	5	0 86
0209–0543	,, 20 ,,	5	0 57
0548–0747	,, 20 ,,	5	0 42
0139–0604	,, 21 ,,	8	0 75
0130–0420	,, 22 ,,	7	0 47
0140–0713	,, 23 ,,	8	0 34
0319–0616	,, 25 ,,	5	0 46
0302–0727	,, 26 ,,	9	0 31
0157–0423	,, 29 ,,	6	0 61
0428–0707	,, 29 ,,	5	<0 16
0105–0439	,, 30 ,,	7	0 19
0444–0733	,, 30 ,,	7	0 30
0313–0502	,, 31 ,,	5	0 28
0133–0448	June 1, 1959	5	0 83
0452–0721	,, 1 ,,	6	0 39
0048–0430	,, 2 ,,	6	0 64
0434–0718	, 2 ,,	7	0 37

The results show that the amount of the emission varies with time, by as much as a factor of 2 in a period of a few hours Attempts are now being made to compare these variations with solar effects and with the low-frequency bursts that are known to come from Jupiter[2], as well as with periodicities due to Jupiter's rotation

An antenna temperature of 1° K would correspond in our case to a brightness temperature of 6,200° K over the surface of Jupiter This high value, together with the time variations, seems to rule out a thermal origin for this radiation The calibration of our system has depended on nightly observations of Virgo *A*, the intensity of which at 1,420 Mc /sec is assumed to be the same as that measured recently by Westerhout[3] at 1,390 Mc /sec

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[1] *New York Times* (May 10 1959)

[2] Carr, T D, *Astro J*, 64, 39 (1959)

[3] Westerhout, G, *Bull Astro Inst Neth*, 14, 215 (1958)

CHEMISTRY

The Coloured Product of the Sakaguchi Reaction

We have already reported[1] that the coloured product of the Sakaguchi reaction[2] (between arginine and α-naphthol) behaves as a typical acid-base indicator, being red in alkali and yellow[3] in acid It has now been found that the compound behaves as an oxidation-reduction indicator also

Long strips of Whatman No 1 filter paper (3 in × 22 in) were soaked in a 0 4 per cent solution of arginine hydrochloride, and dried Colour was then developed, as described earlier[1,3], by dipping first in a solution of 100 mgm α-naphthol, 1 gm urea and 2 5 gm potassium hydroxide in 100 ml ethanol, and finally in a solution of 0 75 gm bromine in 100 ml 5 per cent aqueous potassium hydroxide The colour was dissolved in a minimum quantity of water and the solution, after being acidified with hydrochloric acid (*p*H 2–3), was left overnight in a refrigerator By washing the resulting dark precipitate with cold acidified water and then extracting repeatedly with ether, considerable purification of the compound was achieved

It was observed that on adding a few drops of a freshly prepared solution of sodium dithionite to a dilute and slightly alkaline solution of the above substance, the red colour of the solution was instantly discharged On shaking the solution gently in air, however, the colour reappeared This reversible process could be repeated a large number of times with the same solution When acidified, the yellow colour of the solution could be similarly discharged by dithionite and restored by shaking in air These results were a clear indication of the redox nature of the compound It was found that the compound could also be reduced to the leuco form by stannous chloride, but not by ascorbic acid or cysteine

It appears from these observations that the coloured product of the Sakaguchi reaction has probably a quinonimine portion as its chief chromophore If so then, in view of our recent finding[4] that this reaction is in fact a general reaction of phenolic compounds but is specific for *para*-unsubstituted phenols (a few *p*-halophenols, which gave the reaction, were the sole exception to this rule), the compound must have a *p*-quinonoid structure (as distinct from an *o*-quinonoid one) It would thus appear that the mechanism of colour formation in the Sakaguchi reaction is presumably an oxidative coupling between a guanido compound and a phenol, somewhat as in the formation of an indophenol

Although the present finding, together with the *para*-unsubstituted-phenol specificity of the reaction[4], practically confirms our earlier suggestion regarding a *para*-linkage in the compound[1], it is clear, since the compound behaves as a redox system both in acid and alkali and so must have a quinonoid structure in either, that the variation of its colour in acid and alkali is not due to isomerization between a benzenoid and a quinonoid form as suggested earlier[1] but is due to other factors

The final purification of the compound is in progress with a view to its complete characterization These results, including the exact redox potential of the fully purified compound, will be published later elsewhere

I wish to thank Dr D K Roy and Mr J Datta for their helpful suggestions, and our director, Dr J C Ray, for his kind interest I am also glad to acknowledge the technical assistance of Mr T K Majumdar

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[1] Bhattacharya, K R , Datta, J , and Roy, D K , *Arch Biochem Biophys* , **77**, 297 (1958)

[2] Sakaguchi, S , *J Biochem* (Tokyo), **5**, 25 (1925)

[3] Bhattacharya, K R , Datta, J , and Roy, D K , *Arch Biochem Biophys* (in the press)

[4] Bhattacharya, K R , and Datta, J , Proc Forty-sixth Indian Sci Congr Part 3, Abstracts, 155 (1959)

Reaction-directing Properties of Non-enzymic Macromolecules: Pyrogallol Oxidation in the System Iron(III)–Cellulose

Although the plant cell wall is regarded as an inert substance, mechanical in function, recent studies have demonstrated wall polysaccharides to be active sites (matrices) in the directed polymerization of 4-hydroxyphenylpropene derivatives (such as eugenol) to lignins[1] Other investigations have shown the peroxidation of pyrogallol catalysed by iron(III) to be enhanced by low concentrations of non-enzymic deoxyribonucleic acid[2], and have emphasized both the qualitative and quantitative effects accruing from addition of solid surfaces to various chemical or biochemical systems[3-6]

To extend these views on the catalytic activity of biopolymer surfaces, the system iron(III)–cellulose has been included among those studied as an oxidase model and for its possible direct significance in biocatalysis as well

Among the experimental procedures employed, variables other than cellulose have included concentrations of pyrogallol/hydrogen peroxide (constant molar ratio maintained at 1 5) and iron(III) The formation of coloured oxidation products from pyrogallol at 0 1 and 1 0 m mole/20 ml (after incubation in darkness, at 24±1° C in 0 025 *M* potassium dihydrogen phosphate for 100 hr) was accelerated

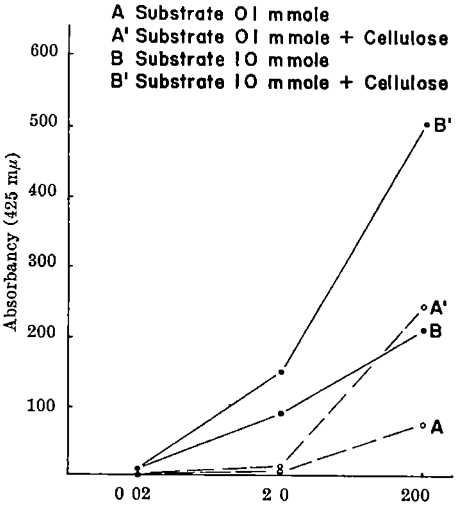

Fig 1

by cellulose (50 mgm Whatman No 42 filter paper) in the presence of iron(III) (Fig 1) With little or no metal ion, addition of filter paper had no effect, whereas at the highest iron(III) concentration 2×10^{-5} mole/20 ml (10^{-3} *M*), addition of filter paper enhanced the reaction 2–3-fold Essentially the same picture is presented both at low and high substrate-levels, however, the combination of intermediate iron(III) concentration (10^{-5} *M*) and low pyrogallol concentration permits only a slight effect of added cellulose, although the effect of cellulose is substantial at this metal ion concentration when more substrate is supplied

When visible (425 mμ, Bausch and Lomb 'Spectronic 20' spectrophotometer) and ultra-violet (260 mμ, Beckman *DU* spectrophotometer) absorbancies were compared, it was noted that, with increase in iron (III) from lowest to highest concentrations, visible absorption increased approximately 20-fold without cellulose and 50-fold in its presence in reaction mixtures with 1 0 m mole of substrate In the same circumstances, ultra-violet absorption increased approximately 5-fold without cellulose, but 15-fold in its presence In effect, then, the relative enhancement by filter paper was somewhat greater when measured in the ultra-violet region The relative effects noted at the lower concentrations of pyrogallol stand in sharp contrast to the preceding, for although there is a 3-fold effect of added filter paper at the highest iron(III) level, only a slight effect (5–20 per cent) of cellulose was in evidence when measurements were made at 260 mμ

The absence of the cellulose effect as measured in the ultra-violet at lower concentrations of pyrogallol and its presence at higher substrate-levels was confirmed separately in a similar experiment using 10^{-5} *M* iron(III) but only a 12-hr reaction-time (Table 1) Here the level of pyrogallol was increased still further, and the products deposited in the filter paper taken into account The importance of substrate concentration is evident here, as the greatest enhancement by added cellulose is found at 1 0 m mole pyrogallol, with a far smaller effect at 10 0 m moles, and essentially none at 0 1 m mole

Table 1 EFFECT OF SUBSTRATE LEVEL AND CELLULOSE ON PYROGALLOL OXIDATION

Pyrogallol (m moles/ 20 ml)	(*a*) Control supernatant	(*b*) Cellulose supernatant	(*c*) In cellulose (extract)	Ratio (*b* + *c*)/*a*
0 1	1 00*	1 00	0 05	1 05
1 0	7 98	14 17	4 52	2 34
10 0	132 0	158 7	5 02	1 24

* Arbitrary, all other absorbancies (260 mμ) computed relative to this value

Substances formed during the oxidation of pyrogallol under the various experimental conditions employed here have not as yet been isolated and characterized chemically, however, some indications as to the diversity of these products have been obtained

The evidence presented here shows the iron(III)-catalysed homogeneous oxidation of a phenol to be enhanced by the presence of a water-insoluble macromolecule of comparatively low reactivity The formation of a two-component catalyst is reminiscent of reconstitution of peroxidases from their separated protein and hæm moieties

The role of a cellulose matrix in biosynthetic processes other than lignification remains a matter of conjecture, but present evidence suggests the importance of the cell wall in biochemical processes

This work was carried out with the support of U S Public Health Service research grant *C*-2730 (National Cancer Institute) while we were in the Department of Biology, University of Rochester

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[1] Siegel S M, *J Amer Chem Soc*, **79**, 1638 (1957)
[2] Siegel, S M, and Siegel, B Z, *Nature*, **179**, 421 (1957)
[3] Keilin, D, and Hartree, E F, *Biochem J*, **44**, 205 (1949)
[4] Newman, M S, and Caflisch, jun, E G, *J Amer Chem Soc*, **80**, 862 (1958)
[5] Slater, E C, *Biochem J*, **45**, 8 (1949)
[6] Siegel, S M, *Proc U S Nat Acad Sci*, **43**, 811 (1957)

Analysis for Magnesium in High-Purity Aluminium

ALTHOUGH there are several methods for determining magnesium in aluminium, very few of these can be used successfully in the low concentration range High-purity aluminium, as supplied by most aluminium manufacturers, usually contains magnesium in the range 1–50 p p m Pohl[1] has developed a chemical method for concentrating the impurities and afterwards analysing by spectroscopy We have developed a distillation method to concentrate the impurities which is more specific than that of Pohl, after the concentration the analysis can be completed by any convenient method

The aluminium stocks analysed were obtained from various suppliers and were supplied as 99 99 or 99 999 per cent pure The apparatus used for the distillation consists of a 'Vycor' bell jar connected to a conventional high vacuum system The sample was heated by induction, and the temperature was determined with an optical pyrometer A graphite plate supported the sample The graphite was of a pure grade which has been developed for nuclear applications, and it had been heated to a high temperature to get rid of any possible magnesium contamination

The procedure is as follows a 10-gm sample (either one piece cut from the billet or a composite) is wet ground, degreased in fresh methanol, etched in concentrated potassium hydroxide and weighed It is then held at a temperature just below the melting point in the apparatus until degassing is completed (10^{-5} mercury) Afterwards, the temperature is raised to 925–1,000° C and held for 10–15 min in a vacuum of about 10^{-5} mm mercury After cooling, the distilled metal which had been condensed on the bell jar is dissolved in distilled hydrochloric acid or aqua regia prepared from distilled acids The solution is analysed by spectroscopy or other convenient means Limited experience indicates that the same results may be obtained by using a small sample, 1 gm, in a graphite or alundum crucible heated in vacuum by a resistance furnace

Results for four aluminium stocks are given in Table 1

There is a small temperature effect in the analysis There is also a small effect of the magnesium/aluminium ratio in the solution, which variation is affected by variation in the time and temperature of distillation However, both these effects are quite small, and the greater errors are those of routine spectro-

Table 1

Aluminium stock	No of samples	Time (min)	Temperature (° C)	p p m magnesium (± average deviation)
A	4	14	950	1 6 ± 0 2
B	4	13	940	1 1 ± 0 2
C	2	12	950	8 6 ± 0 6
D	7	12	920	11 4 ± 3 2
D	3	15	1,000	12 6 ± 1 0

graphic analyses The minimum concentration of magnesium in aluminium which can be found by this method is about 1 p p m

In addition, the concentrations of other low-melting impurities, such as zinc, lead, bismuth and cadmium, may be determined spectroscopically from the acid solutions

We wish to thank J P Faris, B H Meng and M R Trahey for the spectroscopic analyses This work was done under the auspices of the U S Atomic Energy Commission

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[1] Pohl, F A , *Z Anal Chem* , **142**, 19 (1954)

Volatile Methoxides of Aluminium and Zirconium

THE methoxides of the alkali metals, magnesium, aluminium and zirconium were considered to be non-volatile due to their being either ionic or highly polymeric covalent in nature Thus by contrast the penta-methoxides of quinquevalent niobium[1] (dimer), tantalum[2] (dimer) or uranium[3] (trimer) may be distilled under a pressure of 0 1 mm. mercury According to our structural theory for metal alkoxides[4] it seemed possible that the degree of polymerization of aluminium trimethoxide or zirconium tetramethoxide could be as low as 8-fold and approximate calculations suggested that such compounds might be volatile at temperatures greater than 200° C Moreover, recent studies on the thermal stability of metal alkoxides[5] suggested that the methoxides would remain stable up to about 400° C Accordingly we have attempted to sublime some of the 'non-volatile' methoxides in an all-glass molecular still at very low pressure

Aluminium methoxide A sample prepared by the reaction catalysed by mercuric chloride and involving aluminium foil and methanol was heated at 150° C and about 10^{-5} mm mercury and after 24 hr a trace of sublimate had appeared The temperature was then raised to 240° C and a rapid sublimation occurred (found. Al, 22 7 , OMe, 77 2 per cent, $Al(OMe)_3$ requires Al, 22 5 , OMe, 77 5 per cent) It was noticed that freshly sublimed aluminium methoxide dislodged from the cold finger volatilized much more rapidly than the original unsublimed material and suggested a difference in their degrees of polymerization (see ref 4 on 'ageing' of aluminium alkoxides) Samples of sublimed and unsublimed compound were sealed-off in capillaries for X-ray powder photographs The sublimate gave a broad diffraction ring of small radius (Fig 1*A*) suggesting a low order of crystallinity while the unsublimed material gave a similar picture (Fig 1*B*) but with an additional ring of larger diameter Both samples were then exposed to the atmosphere by breaking the ends of the capillaries In each case X-ray pictures showed that hydrolysis had caused a complete breakdown of structure Another sample of sublimate kept in a sealed capillary for one month showed no change in diffraction pattern Similarly, a sample of sublimate kept in contact with dry methanol for a month also showed no major structural change On the other hand, microscopic examination of sublimate suspended in benzene showed that it was initially isotropic but during one month became anisotropic (straight extinction) with isotropic bands It appears, therefore, that the methoxide exhibits a structural 'ageing' effect although the low degree of order in the solid makes difficult the observation of this effect by X-ray powder photography It was also noteworthy that the freshly sublimed compound was practically insoluble in methanol or benzene

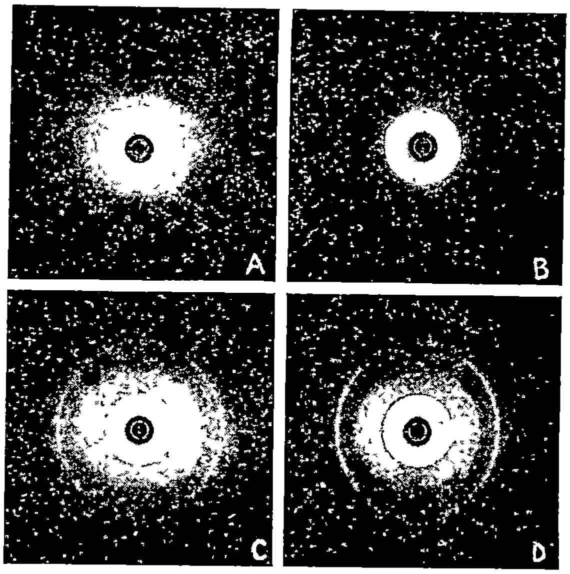

Fig 1

Zirconium methoxide A sample was prepared from redistilled zirconium tetra-*tert* -amyloxide by repeated treatments of the precipitated solid with fresh quantities of boiling methanol Finally the zirconium tetramethoxide (found Zr, 42 2 per cent , $Zr(OMe)_4$ requires Zr, 42 4 per cent) was dried at 190° C and 0 1 mm mercury A sample heated in the molecular still at 250° C slowly gave a sublimate but at 280° C sublimation was rapid and complete (found Zr, 42 6 , OMe, 57 1 per cent , $Zr(OMe)_4$ requires Zr, 42 4 , OMe, 57 6 per cent) X-ray powder diffraction patterns of the sublimed (Fig 1*C*) and unsublimed (Fig 1*D*) solids were very similar and showed a large number of well-defined rings indicating a highly crystalline substance Exposure of the samples to the air caused destruction of the patterns except for one diffuse ring of large diameter The solids were anisotropic

Lithium, magnesium and lanthanum methoxides None of these solids showed any evidence of sublimation at 360° C during a period of 18 hr in the molecular still but they remained completely stable This does not prove that these compounds are ionic and indeed the structural theory would suggest that if they are covalent the lithium and magnesium methoxides should be giant polymers (assuming co-ordination numbers of 4 and 6 for lithium and magnesium respectively) while the minimum polymer for $La(OMe)_3$ with 6 co-ordinated lanthanum would be an octamer (note that lanthanum *tert*-butoxide is volatile[6])

We thank Dr H Carlisle for assistance with the X-ray studies and the Director, Atomic Energy Research Establishment, Harwell, for permission to publish these results

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[1] Bradley, D C , Chakravarti, B N , and Wardlaw, W , *J Chem Soc* , 2381 (1956)
[2] Bradley, D C , Wardlaw, W , and Whitley, A , *J Chem Soc* , 728 (1955)
[3] Bradley, D C , and Chatterjee, Amar K , *J Inorg Nuclear Chem* , **4**, 279 (1957)
[4] Bradley, D C , *Nature*, **182**, 1211 (1958)
[5] Bradley, D C , and Faktor, M M , *J Appl Chem* (in the press)
[6] Bradley, D C , and Faktor, M M , *Chem and Indust* , 1332 (1958)

BIOCHEMISTRY and PHYSIOLOGY

Role of the Coenzyme in the Stabilization of Glyceraldehyde-3-phosphate Dehydrogenase

THE role of a coenzyme is studied mostly with respect to the mechanism of reactions catalysed by specific enzymes It has been established in some cases that coenzymes and prosthetic groups have a protecting and stabilizing effect on the protein molecule It is known that the large molecule of D-glyceraldehyde-3-phosphate dehydrogenase (PGAD) (molecular weight 140,000) is labile, and does not contain disulphide linkages as stabilizing bonds[1]

According to Velick crystalline D-glyceraldehyde-3-phosphate dehydrogenase from rabbit skeletal muscle binds firmly 3 moles of diphosphopyridine nucleotide (DPN) per mole of protein[2] We have found that crystalline D-glyceraldehyde-3-phosphate dehydrogenase from beef, pig and dog also bind firmly the same amount of coenzyme[3] It is presumed[1] that the firmly bound diphosphopyridine nucleotide has a stabilizing role and, as we have previously found, in the presence of excess diphosphopyridine nucleotide D-glyceraldehyde-3-phosphate dehydrogenase is fully resistant to the proteolytic action of trypsin[4] Therefore, we studied the role of diphosphopyridine nucleotide in connexion with its stabilizing effect on the D-glyceraldehyde-3-phosphate dehydrogenase molecule, by measuring the changes in the specific optical rotation, intrinsic viscosity and digestibility occurring as a result of displacement of the bound coenzyme from the enzyme molecule by charcoal treatment and *p*-chloromercuribenzoate (PCMB) blocking[1]

The experiments were carried out with four times recrystallized pig D-glyceraldehyde-3-phosphate dehydrogenase, prepared according to the method of Elödi and Szorényi[3], in a 0 1 M phosphate buffer at *p*H 8 4 Displacement of the bound diphosphopyridine nucleotide was assessed spectrophotometrically at the wave-lengths 250–290 and 330–370 mμ The results are given in Table 1

Table 1 THE EFFECT OF DISPLACEMENT OF THE BOUND COENZYME ON SOME PROPERTIES OF D-GLYCERALDEHYDE-3-PHOSPHATE DEHYDROGENASE

PGAD tested	Spec opt rotation $[\alpha]^{20}_{D}$	Intrinsic viscosity $[\eta]$	Digestibility* by trypsin in 30 min at 35° C
1 Control PGAD $(DPN)_3$	−30 6°	1 95	1 00
2 Control + 3 equiv PCMB	−40 8°	7 80	2 80
3 Charcoal treated	−41 6°	7 30	3 10
4 Charcoal treated + 3 equiv DPN	−29 8°	1 90	0 70
5 Charcoal treated + 6 equiv DPN	−31 4°	2 40	0 14
6 Charcoal treated + 15 equiv DPN	−31 4°	3 05	0 0†
7 Urea denatured	−99 7°	42 5	14 2

* Digestion was carried out with crystalline trypsin The extinction of the deproteinized reaction mixture and the amount of protein precipitable with 6 6 per cent trichloracetic acid were measured The digestibility of the control experiments has been taken arbitrarily as unity

† Digestibility after 3 hr incubation

It can be seen that the displacement of the bound coenzyme causes a change in the structure of the enzyme shown by the changed specific optical rotation and intrinsic viscosity and the enhanced digestibility These changes are in the same direction as those caused by denaturation, the effect, however, being much less pronounced than that caused by treatment with urea

Re-addition of the amount of diphosphopyridine nucleotide displaced from the protein molecule completely restores the initial properties Addition of a greater excess of coenzyme does not alter the optical rotation of the protein, but it increases its intrinsic viscosity and stabilizes the structure of the enzyme against proteolysis

The above results suggest that the bound diphosphopyridine nucleotide stabilizes the structure of the enzyme molecule in a given configuration, which may be necessary to the catalytic action The effect found with excess diphosphopyridine nucleotide requires a more extended experimental analysis

The details of these experiments will be published in *Acta Physiologica Academiae Scientiarum Hungaricae*

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[1] Velick, S F , in McElroy, W D , and Glass, B , ed , "The Mechanism of Enzyme Action", 491 (Johns Hopkins Press, Baltimore, 1954)
[2] Velick, S F , *J Biol Chem* , **233**, 1455 (1958)
[3] Elodi, P , and Szorényi, E , *Acta Physiol Hung* , **9**, 339 (1956)
[4] Szabolcsi, G , *Acta Physiol Hung* , **13**, 214 (1958)

ε-N-Methyl-lysine in Bacterial Flagellar Protein

FLAGELLAR proteins (flagellins) from several species of bacteria have been studied by Weibull[1] and, more recently, by Koffler[2] The present investigations have revealed differences in the amino-acid compositions of the flagellins from *Proteus vulgaris*[2] and *Salmonella typhimurium* (Table 1) Also the latter protein has been found to contain ε-N-methyl-lysine, an amino-acid that has not been previously found to occur naturally

Table 1 AMINO-ACID COMPOSITION OF FLAGELLINS
From (*A*) *Salmonella typhimurium SW*1061 two independent determinations
From (*B*) *Proteus vulgaris* (Koffler, ref 2) recalculated for comparison purposes
Results expressed as gm residues/10^5 gm protein

	(*A*)		(*B*)
Glycine	79	81	86
Alanine	147	150	110
Valine	60	60	64
Leucine	74	76	86
*iso*Leucine	49	46	56
Glutamic acid	96	96	97
Aspartic acid	155	153	166
Serine	59	57	68
Threonine	101	99	85
Tyrosine	20	27	13
Phenylalanine	13	14	24
Tryptophan	0	0	0
Proline	13	9	0
Cystine/2	0	0	6
Methionine	3	3	7
Lysine	33	31	49
ε-N-methyl-lysine	28	24	0
Arginine	24	29	40
Histidine	4	0	0
Total residues	958	955	957
Amide groups	156	152	144

ε-N-methyl-lysine was identified in hydrochloric acid hydrolysates of the flagellin by paper electrophoresis, and by chromatography on paper (Fig 1) and ion-exchange resin In several systems the amino-acid from flagellin behaved in a similar way to a sample of synthetic ε-N-methyl-lysine (obtained from Dr F Sanger Neuberger and Sanger[3]), and could be differentiated from the isomeric α-N-methyl-lysine and homolysine The ε-N-methyl-lysine from flagellin was separated from the other hydrolysis products by ion-exchange chromatography, and was crystallized as the monohydrochloride Elementary analysis agreed with the formula $C_7H_{17}N_2O_2Cl$ (calculated C, 42 8, H, 8 65, N, 14 3, found C, 42 7, H, 8 91, N, 14 5) The bacteria were found to incorporate lysine-^{14}C into the flagella both as lysine and as the new amino-acid, under conditions in which no other amino-acid was made radioactive Dinitrophenyl-flagellin, on hydrochloric acid hydrolysis, yielded two yellow water-soluble components, namely, ε-dinitrophenyl-lysine and ε-dinitrophenyl-ε-N-methyl-lysine The latter was characterized by the R_F value, the absorption spectrum (with a maximum at 388 mμ), and by hydrolysis with an ammonia solution to give the free amino-acid Peptides from tryptic and chymotryptic digests of flagellin were separated by paper electrophoresis, several peptides were found to contain ε-N-methyl-lysine, and the ratio of lysine to ε-N-methyl-lysine varied from peptide to peptide, indicating that ε-N-methyl-lysine occurs at several sites in the polypeptide chain

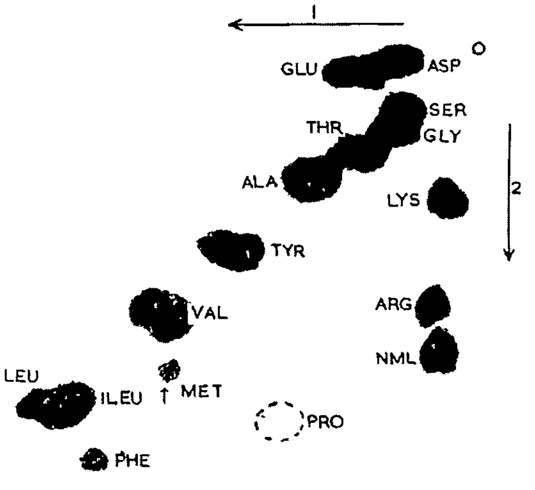

Fig 1 Two-dimensional chromatogram of a 24-hr 105° C, 6 *N* hydrochloric acid hydrolysate of 0 2 mgm of *Salmonella typhimurium SW*1061 flagellin Method of Levy and Chung (ref 4) Solvent 1 *n*-butanol/acetic acid/water (4 1 5) Solvent 2 1 1 *m*-cresol/phenol, *p*H 9 3 borate buffer Whatman No 52 paper NML, ε-N-methyl-lysine

The organism used for most of the experiments was *Salmonella typhimurium* strain *SW*1061, and was normally grown on a broth/agar medium In the isolation of crystalline ε-N-methyl-lysine monohydrochloride, when large amounts of starting material were required, some flagella from other *Salmonella* species were used

Our thanks are due to Drs B A D Stocker and D Kerridge for material, to Dr F Sanger for advice, and to Miss B Worboys for assistance

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[1] Weibull, C, *Acta Chem Scand*, **5**, 529 (1951), **7**, 335 (1953)

[2] Koffler, H, *Bact Revs*, **21**, 227 (1957) Rinker, N J, Kobayashi, T, and Koffler, H, *Fed Proc*, **16**, 238 (1957)

[3] Neuberger, A, and Sanger, F, *Biochem J*, **38**, 125 (1944)

[4] Levy, A L, and Chung, D, *Anal Chem*, **25**, 396 (1953)

Inhibitory Effect of Fungistatic Antibiotics on the Production of Amylase by *Penicillium chrysogenum*

THE washed mycelium of *Penicillium chrysogenum* is able to synthesize amylase in the presence of starch The production of this enzyme starts after 4 hr incubation independently of the original carbohydrate content of the medium 150–250 u enzyme/100 ml will be produced during further incubation for the next 4–6 hr This enzyme production was inhibited by 2,4-dinitrophenol (3 × 10^{-4} *M*) and sodium azide (10^{-4} *M*), but was not influenced by streptomycin (2,000 μgm/ml), chloramphenicol (200 μgm/ml) or oxytetracycline (500 μgm/ml) The effect of the fungistatic antibiotics on the production of the enzyme was examined under experimental conditions identical with those previously reported[1] Aqueous dilutions of solution of the fungistatic substances in methanol were added to the incubated mixture Amylase was determined by the method of Smith and Roe[2], the results (Table 1) show that production of this enzyme is very sensitive to the presence of the substances mentioned above

Shepherd[7] and Kerridge[8] observed that with *Aspergillus nidulans* and *Saccharomyces carlsbergensis*, respectively, synthesis of protein and of nucleic acid was inhibited by antibiotics only in growth-inhibiting concentrations Furthermore, Kerridge found[8] that 'Actidion' is able to influence the synthesis of the adaptive maltozymase system in concentrations

Table 1. INHIBITION OF AMYLASE PRODUCTION (PER CENT)

	Concentration of the antibiotics (μgm./ml.) 100	10	1	0.1	0.01
Nystatin (ref. 3)	100	100	90	45	25
Flavofungin (ref. 4)	95	20	0	0	0
Trichotecin (ref. 5)	100	80	60	10	0
T-substance* (ref. 6)	100	80	60	10	0

* A new antibiotic similar to trichotecin.

below that necessary to inhibit growth. Our results are similar to those cited. It is striking, however, that nystatin inhibits the production of amylase at a much lower concentration than other fungistatic antibiotics, at a concentration, moreover, at which it exerts no fungistatic action. This fact may play a prominent part in the therapeutical applicability of nystatin.

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[1] Horvath, I., Bajusz, S., and Szentirmai, A., *Nature*, **183**, 477 (1959).
[2] Smith, M. B., and Roe, J. H., *J. Biol. Chem.*, **179**, 53 (1949).
[3] Hazen, E. L., and Brown, R., *Proc. Soc. Exp. Biol. Med.*, **76**, 93 (1951).
[4] Uri, J., and Békési, I., *Nature*, **181**, 908 (1958).
[5] Freeman, G. G., and Morrison, R. I., *Nature*, **162**, 30 (1948).
[6] Glaz, E., *et al.* (private communication).
[7] Shepherd, C. J., *J. Gen. Microbiol.*, **19**, 497 (1958).
[8] Kerridge, D., *J. Gen. Microbiol.*, **19**, 497 (1958).

Detection and Identification of the Polyphenoloxidase Substrate of the Banana

BLACKENING of the fruit of the banana may occur during cultivation, when the cause is usually of pathological origin, or during storage if ripening is not adequately controlled. The biochemical changes involved in the blackening of the fruit have received little study, although evidence for the existence of an enzyme system in the fruit of the banana capable of oxidizing substances of the catechol type was presented by Onslow[1] in 1920. The existence of flavonoid compounds in the edible banana has been reported[2,3]. Robinson[2] detected delphinidin in the hydrolysis products of the pulp of an edible banana while Simmonds[3], who has described the anthocyanin pigments of the bracts of a number of banana species in detail, reported that the skin and pulp of fruit of the edible varieties contained large amounts of leucoanthocyanins. Indirect evidence was, however, obtained[3] that the polyphenol oxidase system of the banana was unable to act on the leucoanthocyanins present to produce brown colorations. Recently, the presence of serotonin and related compounds in the fruit of the banana was reported by Waalkes *et al.*[5] The ability of these compounds to serve as substrates for polyphenoloxidase was not, however, explored.

During the past year, chromatographic studies at the Imperial College of Tropical Agriculture have indicated that the major browning substrate of the edible banana is 3,4-dihydroxyphenylethylamine and have confirmed the opinion of Simmonds that the leucoanthocyanins present are not acted upon by banana polyphenoloxidase.

Two varieties of banana were utilized in these studies: the clone Gros Michel, which is extensively cultivated in tropical America and to a more limited extent in Jamaica for export, and the clone Mysore, which is grown wholly for local consumption. The polyphenols of the banana skin were extracted by macerating 25 gm. of tissue in 50 ml. of 1 per cent methanolic hydrochloric acid. After filtration, 0.02 ml. of this extract was applied to the chromatogram, which was developed with butanol/acetic acid/water (40:10:50). After drying, the chromatogram was sprayed with a polyphenoloxidase preparation and incubated in a humid chamber[6] until the browning changes were complete. A single zone showing intense darkening developed on the chromatogram and after drying its position was marked. By this means it was shown that the major browning substrate of the banana possessed an R_F of 0.42 in butanol/acetic acid/water. Although a large amount of stationary leucoanthocyanin was present on the base-line (evidenced by a high yield of the anthocyanidin, delphinidin on acid hydrolysis of the strip), no browning occurred in this region. These results were later confirmed by two-dimensional chromatography, in which primary development with 2 per cent acetic acid was followed by a secondary development with the butanol/acetic acid/water solvent system.

The enzyme preparations used to locate the browning substrate were (*a*) banana polyphenoloxidase, (*b*) cacao polyphenoloxidase[6] and (*c*) tyrosinase (from mushrooms, L. Light and Co., Ltd.). The last two enzymes were applied to the chromatogram as aqueous or buffered solution by means of a glass spray[6]. The application of the banana enzyme to the chromatogram was complicated by its relative insolubility in water, the activity being almost wholly lost on filtration. Since spraying the unfiltered suspension was impracticable, application of the enzyme preparation was effected by the following means: 25 gm. of banana pulp in 50 ml. of distilled water was homogenized in a microblender for 10 min., after which the crude suspension was applied to the chromatogram by means of a small nylon brush, which was dipped into the suspension and then caused to emit a spray by passing a glass rod firmly and rapidly over the bristles. The semi-solid suspension was thus evenly distributed over the chromatogram and on incubation a well-defined area of browning, corresponding in position to that given by the other polyphenoloxidase preparations, formed on the chromatogram.

Since the crude banana extract possessed similar activity to the well-characterized polyphenoloxidases of the mushroom and cacao, it is evident that a highly active phenol oxidizing system is present in the fruit of the banana, and it was shown that aqueous extracts of banana pulp possessed the ability to oxidize added (—)-epi-catechin and catechol at a rapid rate.

Comparison of the chromatographic properties of the browning substrate with those of the naturally occurring phenolic acids and flavonoids indicated that the substance did not correspond to any previously reported compound in either of these groups. With certain spray reagents, however, the colours given closely resembled those given by 3,4-dihydroxyphenylalanine, and it appeared that although the R_F values of these two compounds differed considerably, there was a strong possibility that the

Table 1

		Browning substrate	3,4-Dihydroxyphenylethylamine
R_F values	Butanol/acetic acid/water (40 10 50)	0 42	0 42
	2 per cent acetic acid	0 69	0 69
	phenol/sulphur dioxide (ref 5)	0 43	0 43
Spray reagents	*p*-nitro-aniline (ref 4)	brown→purple→black	brown→purple→black
	Potassium ferricyanide (ref 5)	pink→lavender	pink→lavender
	ultra-violet fluorescence after spraying with potassium ferricyanide	blue	blue
	1 per cent ethanolic ferric chloride	pale olive green	pale olive green

browning substrate was closely related chemically to the latter substance It was later shown that the browning substrate was chromatographically identical with an authentic specimen of 3,4-dihydroxyphenylethylamine (Delta Chemical Works Inc) (Table 1)

3,4-Dihydroxyphenylethylamine was shown to be present in both skin and pulp of the edible banana Although the amount present in the pulp was very much lower than that found in the skin, its presence was readily demonstrated chromatographically by a preliminary concentration of the pulp extract in a vacuum oven 3,4-Dihydroxyphenylethylamine was detected also in other parts of the banana plant, including the bracts of the flower Although the amine was present in large amounts, the corresponding amino-acid, 3,4-dihydroxyphenylalanine, was not detected in any of the extracts examined

Examination of banana skin in which blackening was pronounced showed that the content of 3,4-dihydroxyphenylethylamine was low or nil A similar decrease resulted when skin tissue was macerated in water Under these conditions an immediate darkening occurred and afterwards 3,4-dihydroxyphenylethylamine could not be detected in the reaction mixture When the maceration was carried out in 1 per cent hydrochloric acid, or when the tissue was first dropped into boiling water to arrest enzymic action, no darkening occurred and 3,4-dihydroxyphenylethylamine could be detected in normal quantity These observations provide confirmation that 3,4-dihydroxyphenylethylamine is the natural precursor of the black pigment observed in oxidized banana tissue

I wish to express my appreciation to Mr N W Simmonds for much helpful advice and for assistance in obtaining plant material for these and related studies

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[1] Onslow, M W , *Biochem J* , **14**, 541 (1920)
[2] Robinson, G M , *J Chem Soc* , 1157 (1937)
[3] Simmonds, N W , *Ann Bot* , N S , **18**, 471 (1954)
[4] Swain T , *Biochem J* , **53**, 200 (1953)
[5] Waalkes, T P , Sjoerdsma, A , Creveling, C R , Weissbach, H , and Udenfried, S , *Science*, **127**, 648 (1958)
[6] Griffiths, L A , *Nature*, **180**, 1373 (1957)

Lipase Activity in the Brown and Yellow Adipose Tissue of the Bat

OUR histochemical observations on the brown and yellow adipose tissue of the bat, *Hipposideros speoris*, showed that the activity of lipase is more or less the same in the two types of adipose tissue (unpublished) Fawcett[1], using histochemical methods, reported a much higher concentration of lipase in the brown than the yellow adipose tissue of the rat Here we report the results of a quantitative study of lipase activity in the brown and yellow adipose tissue of the bat, *Hipposideros speoris*

The enzyme material used was an aqueous extract of ether-defatted brown and yellow adipose tissue prepared in the following manner After decapitation, the subcutaneous interscapular brown adipose tissue and the yellow adipose tissue from the lower lateral sides of the abdomen were carefully removed and separately minced, defatted in two changes of ethyl ether at room temperature for 2 hr and dried in a vacuum desiccator at room temperature Extracts of the material were made by grinding with clean sand in cold distilled water in a test-tube for 1 hr and centrifuging at about 2,500 r p m for 5 min The supernatant was used for the study The method used for the assay was a manometric method adopted from Martin and Peers[2] using the Warburg apparatus, with a bicarbonate–carbon dioxide buffer system *p*H 7 4 at 37° C using tributyrin as substrate The reaction flask contained 1 5 ml of 0 025 *M* bicarbonate solution, 1 ml enzyme solution in the main chamber and 0 5 ml 4 per cent (v/v) tributyrin in 0 0148 *M* bicarbonate (emulsified by shaking with a drop of 'Tween 80') in the side arm, making a total volume of 3 ml The manometers and flasks were gassed for 3 min with a mixture of 95 per cent nitrogen and 5 per cent carbon dioxide from a cylinder After equilibration for 10 min the substrate was tipped in and two readings taken at intervals of 30 min The manometers were shaken at about 100 oscillations/min with an amplitude of 4–5 cm per oscillation

Lipase activity was calculated on the basis of the protein concentration of the enzyme solution used and is expressed as µl carbon dioxide produced/mgm protein/hr Protein was estimated by the micro-Kjeldahl method for total proteins[3]

Table 1 LIPASE ACTIVITY IN THE ADIPOSE TISSUES FROM ABOUT 35 BATS

Tissue	Lipase activity (μl CO_2/mgm protein/hr)
Brown adipose	30 45
Yellow adipose	37 85

From the results obtained it is evident that the yellow adipose tissue has a higher lipase activity than the brown, but at the same time the difference in concentration of the enzyme in the two types of adipose tissue is not sufficient to show a pronounced difference in histochemical preparations Among the other enzymes studied by histochemical methods (George and Eapen, unpublished) a distinct difference was observed only in the case of the dehydrogenases, such as succinic and lactic dehydrogenases, occurring in much higher concentrations in the brown than in the yellow adipose tissue Fat in the yellow adipose tissue is reported to be mobilized in greater concentration and at a faster rate than in the brown adipose tissue[4] This could be accounted for by the higher concentration of lipase in the yellow adipose tissue It may also be mentioned that the lipase activity in the pigeon adipose tissue is about six times greater than in the yellow adipose tissue in this bat[5]

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[1] Fawcett, D W , *J Morph* , **90**, 363 (1952)
[2] Martin, H F , and Peers, F G , *Biochem J* , **55**, 523 (1953)
[3] Hawk, P B , Oser, B L , and Summerson, W H , "Practical Physiological Chemistry" (McGraw-Hill, New York, 1954)
[4] Remillard, G L , *Ann N Y Acad Sci*, **72**, 1 (1958)
[5] George, J C , and Eapen, J , *J Anim Morph Physiol* , **5**, 49 (1958)

'On'- and 'Off'-Responses of the Olfactory Epithelium

SLOW-action potentials have been found in various sensory receptors in response to adequate stimuli They were first found in the olfactory epithelium of a dog by Hosoya and Yoshida[1] Recently, Ottoson[2] studied them extensively in the olfactory epithelium of a frog He showed that the action potential is of a triangular shape, having a steeply rising limb, a round summit and a gradually falling limb in an exponential curve When the duration of the olfactory stimulus is long, a plateau appears in the middle of the falling limb and continues as long as the stimulation It is succeeded by an exponentially falling limb at the cessation of stimulation

In the course of our experiments on the olfactory epithelium of a frog and a toad, action potentials were frequently found at the cessation of stimulation Thus, two slow-action potentials appeared at the onset and the cessation of stimulation (Fig 1, *b*, *c* and *d*) These phenomena are well known in the retina[3], in the optic nerve[4] and in the auditory nerve[5] They are called 'on'- and 'off'- responses respectively It is interesting that similar phenomena were found in the olfactory epithelium as well

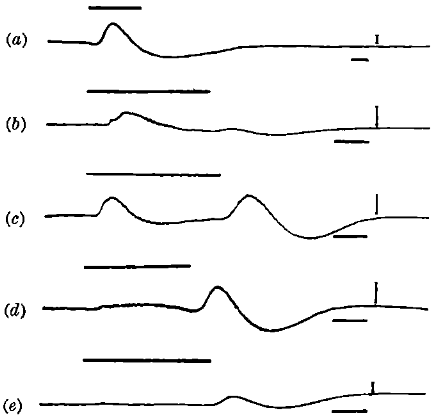

Fig 1 On- and off-responses (*a*), On-response (*b*), (*c*) and (*d*), Various types of on–off-responses The on-response is bigger than the off-response in (*b*) and vice versa in (*d*) (*e*), Off-response The horizontal lines above the potentials on the left indicate the durations of olfactory stimulation The vertical and horizontal bars on the right show 50 μV and 1 sec respectively

In order to study the stability of these response types, olfactory stimulation of the same odour and same intensity was repeated It was found that the shapes and magnitudes of the potentials varied from time to time An instance of such variability was shown in Fig 1, *b*, *c* and *d* The on-response is bigger than the off-response in Fig 1, *b*, but vice versa in Fig 1, *d* These differing results were obtained in the same epithelium by successive stimulation From these observations, it is supposed that the relation between the on- and off-responses is not simple and steady in the olfactory epithelium In a few cases only the off-responses appeared (Fig 1, *e*) Thus, in the olfactory epithelium of a frog and a toad, three types of responses, pure on-, pure off- and on–off-, were observed

The olfactory epithelium is a single cell layer, constituted by the olfactory and sustentacular cells arranged in parallel A synapse has not been found in the epithelium Consequently, it is supposed that these responses are produced by the activity of the olfactory cells Dogiel[6] and Jagadowski[7] described three types of receptor cell—one spindle shaped, one columnar and one conical Though these findings have not been confirmed by other histologists, it is presumed that there may be two or three types of the olfactory cells, corresponding to the on- and off-, or on-, off-, and on–off-responses

Detailed results and discussion will be published elsewhere

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[1] Hosoya, Y , and Yoshida, H , *Jap J Med Sci* , III *Biophys* , **5**, 22 (1937)
[2] Ottoson, D , *Acta Physiol Scand* , **35**, Supp , 122 (1956)
[3] Granit, R , "Sensory Mechanisms of the Retina" (Oxford University Press, London, 1947)
[4] Hartline, H K , *Amer J Physiol* , **121**, 400 (1938)
[5] Galambos, R , *J Neurophysiol* , **15**, 381 (1952)
[6] Dogiel, A , *Arch Mikr Anat* , **26**, 50 (1886)
[7] Jagadowski, K P , *Anat Anz* , **19**, 257 (1901)

Synthesis of Diphosphopyridine Nucleotide from Nicotinamide by Slices of Liver

FOLLOWING the injection of nicotinamide, large increases in the diphosphopyridine nucleotide content of mouse tissues, particularly liver, have been reported by Kaplan and co-workers[1] Although it is thought that diphosphopyridine nucleotide is synthesized from adenine mononucleotide, the increase in the former is accompanied by an increase in the total acid-soluble adenine content of the liver

The present work shows that contrary to other reports[2] there is an increase in the content of diphosphopyridine nucleotide of rat and mouse liver incubated in oxygen *in vitro* in the presence of nicotinamide Three- to four-fold increases in content of diphosphopyridine nucleotide were obtained both *in vitro* in the presence of 10^{-2} *M* nicotinamide and *in vivo* after the injection of 500 mgm /kgm nicotinamide The levels of triphosphopyridine nucleotide were unaffected

In vitro the formation of diphosphopyridine nucleotide is at the expense of adenine mononucleotide (Table 1), as is to be expected if the former is formed from adenosine triphosphate and nicotinic acid or

Table 1. EFFECT OF NICOTINAMIDE ON THE LEVELS OF ADENINE NUCLEOTIDES IN RAT LIVER

	No. of experiments	µmoles/gm. frozen tissue. Means ± standard error			
		DPN	Analogue	Sum ATP+ADP+AMP	ATP
Control slices	11	0.22 ± 0.01	0	1.15 ± 0.07	0.62 ± 0.05
Slices + 10^{-2} M nicotinamide	11	0.66 ± 0.06*	0.32 ± 0.06	0.65 ± 0.07*	0.34 ± 0.05*
Change		+0.44	+ 0.32	− 0.50	− 0.28
Control rats	7	0.60 ± 0.05	0	3.77 ± 0.11	1.12 ± 0.17
Nicotinamide-treated rats (500 mgm./kgm.)	4	2.31 ± 0.14*	0.44 ± 0.03	3.19 ± 0.17	1.05 ± 0.18
Change		+ 1.71	+ 0.44	− 0.58	− 0.07

* Significantly different from corresponding control mean at $P < 0.001$.

Slices were weighed after freezing in liquid nitrogen following a 3-hr. incubation in Krebs–Ringer–phosphate medium in conventional Warburg apparatus. Gas phase oxygen, glucose 200 mgm. per cent. Nucleotides were separated and estimated using two-dimensional chromatography (*iso*butyric acid–ammonia and acetone–water systems) as previously described (ref. 7). Three approximately 100-mgm. slices were pooled for each determination and the nucleotides in the perchloric acid extract were adsorbed on to 50 mgm. 'Norit' columns.

Liver samples were quickly removed from decapitated rats 3 hr. after the intraperitoneal injection of nicotinamide, frozen in liquid nitrogen, and the nucleotides separated and estimated as above, using 150 mgm. 'Norit' columns. DPN, Diphosphopyridine nucleotide; AMP, ADP and ATP, adenosine mono-, di- and tri-phosphate.

nicotinamide mononucleotides[3,4]. *In vivo* the total adenine nucleotide concentration rises. It is clear that liver slices cannot replace the adenine mononucleotide used in this synthesis as readily as the intact liver.

Mouse liver slices behaved similarly, twofold increases in diphosphopyridine nucleotide being obtained.

Chromatograms of the nucleotides in rat and mouse liver slices after incubation with nicotinamide, and in liver of both species after the injection of nicotinamide, showed the presence of an ultra-violet-absorbing spot not present in the controls. The compound has been identified on the following grounds as the nicotinic acid analogue of diphosphopyridine nucleotide: (1) The appearance of a peak at 315 mµ in the absorption curve following the addition of potassium cyanide. (2) A phosphorus to adenine to ribose ratio of 2 : 1 : 2. (3) The electrophoretic pattern of the new compound after alkaline hydrolysis differed from that of similarly treated diphosphopyridine nucleotide only in the presence of a compound migrating with nicotinic acid and the absence of nicotinamide. (4) The compound co-chromatographed with the synthetic nicotinic acid analogue in the two-dimensional system used. (5) The compound and the synthetic analogue were not reduced by alcohol dehydrogenase, thus distinguishing them from diphosphopyridine nucleotide. The incorporation of nicotinic acid labelled with carbon-14 into diphosphopyridine nucleotide by human erythrocytes[5] and the synthesis of the nicotinic acid analogue by mouse liver[6] suggested that nicotinic acid itself might be utilized by liver slices for the synthesis of diphosphopyridine nucleotide. However, the incubation of rat liver slices in the presence of 10^{-2} M nicotinic acid did not lead to the formation of diphosphopyridine nucleotide or its nicotinic acid analogue. Kaplan has shown *in vivo* also that nicotinic acid does not markedly increase the level of diphosphopyridine nucleotide.

On the addition of phosphorus-32 to the incubation medium containing 10^{-2} M nicotinamide and rat liver slices the nicotinic acid analogue had a much higher specific activity than the diphosphopyridine nucleotide, suggesting that it was a precursor and not a breakdown product of the latter (Table 2).

Table 2. THE INCORPORATION OF PHOSPHORUS-32 INTO DIPHOSPHOPYRIDINE NUCLEOTIDE AND ITS NICOTINIC ACID ANALOGUE *in vitro*

	Specific activity (counts/min./mgm./P)
Diphosphopyridine nucleotide	14,700
Nicotinic acid analogue	65,700

Slices were incubated as in Table 1. 10 µc. phosphorus-32 added from side arm after 2-hr. incubation.

These results are consistent with current ideas[3] that nicotinic acid mono- and di-nucleotides are intermediates in the biosynthesis of diphosphopyridine nucleotide but do not explain why nicotinic acid does not lead to increased levels of diphosphopyridine nucleotide following incubation of slices or injection *in vivo*.

I wish to thank Prof. N. O. Kaplan for supplying the synthetic diphosphopyridine nucleotide analogue and Mr. R. Manston for skilled technical assistance.

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[1] Kaplan, N. O., Goldin, A., Humphreys, S. R., Ciotti, M. M., and Stolzenback, F. E., *J. Biol. Chem.*, **219**, 287 (1956).

[2] Shuster, L., Langan, T. A., Kaplan, N. O., and Goldin, A., *Nature*, **182**, 512 (1958).

[3] Handler, P., Symposium on Vitamins, Fourth International Congress of Biochemistry, Vienna (1958).

[4] Kornberg, A., *J. Biol. Chem.*, **182**, 779 (1950).

[5] Preiss, J., and Handler, P., *J. Biol. Chem.*, **233**, 488 (1958).

[6] Langan, T. A., and Shuster, L., *Fed. Proc.*, **17**, 260 (1958).

[7] Threlfall, C. J., *Biochem. J.*, **65**, 694 (1957).

Increased Circulating Insulin-like Activity in Obese-Hyperglycæmic Mice

THE hereditary obese-hyperglycæmic syndrome of mice is a condition characterized by extreme adiposity, hyperglycæmia, hypercholesterolæmia, and a variety of metabolic, endocrine, enzymatic and behavioural idiosyncrasies[1-3]. High blood glucose values are observed under conditions of *ad libitum* feeding in spite of an increased insulin content of the pancreas, extensive hypertrophy of the islets of Langerhans and marked hyperplasia and degranulation of the beta-cells[4].

The availability of the bioassay recently developed by Martin *et al.*[5] offered an opportunity to compare the insulin-like activity in the serum of obese-hyperglycæmic mice and their lean litter-mates, both in fed and fasted states. This bioassay is based on the observation that insulin increases the *in vitro* oxidation of glucose-1-^{14}C by rat epididymal fat, there existing a satisfactory linear correlation between the square root of this effect and the logarithm of the insulin-level[6]. 133 three months old adult mice and

Table 1 Circulating Insulin-like Activity in Obese-Hyperglycæmic Mice and their Non-obese Litter-mates

Experimental series	Slope of response log dose line	Type and status of animals*	Obese				Non-obese			
			Number and sex	Average weight (gm)	Serum glucose (mgm / 100 ml)	Serum insulin-like activity (μunits/ml.)	Number and sex	Average weight (gm)	Serum glucose (mgm / 100 ml)	Serum insulin-like activity (μunits/ml)
1	0 71	Adult Fed	25 (17 M + 8 F)	54	263	$\gg$ 1,000‡	20 F	27	93	107
2	1 27	Adult Fed	21 (11 M + 10 F)	58	198	> 1,000	20 M	25	98	33
3	2 21	Adult Fasted†	19 (10 M + 9 F)	56	70	690	29 F	26	64	114
4	1 52	Ageing Fed	21 (14 M + 7 F)	59	511	87	32 M	32	84	485

* Adult animals are 3 months old , ageing animals are 14 months old (the obese had been reduced and re-fed twice)

† Fasted animals have been deprived of food for 24 hr

‡ The sign $\gg$ indicates that the activity was considerably above 1,000 μunits/ml

53 fourteen months old ageing mice were used Body-weights were 54–59 gm for the obese mice and 25–32 gm for the non-obese The 21 ageing obese mice had been previously subjected to a regimen of alternating undernutrition (and weight loss) and *ad libitum* refeeding (and weight gain) It has been shown[7] that the life expectancy of such animals is shorter than that of animals allowed to gain weight without interruption

1-ml individual blood samples were drawn under light 'Nembutal' anæsthesia from the vena cava or the main thoracic vessels and rapidly centrifuged After a few severely hæmolysed samples had been discarded, the sera were pooled and stored overnight at 5° C Serum glucose was determined by the method of Somogyi–Nelson[8]

For each bioassay, the subdivided epididymal fat pads of 3 test rats (200–250 gm Wistar males) were incubated with 2 ml pooled serum or recrystallized insulin (Eli Lilly batch 366368) diluted serially down to 1,000 and 62 μunits/ml with Krebs–Ringer bicarbonate buffer with 2 mgm /ml gelatin added The glucose concentration of both buffers and sera was made up to 3 mgm /ml containing glucose-1-^{14}C (0 2 μc per flask) In the case of the ageing obese mice the high serum glucose was left unchanged except for the addition of labelled glucose The temperature in the Dubnoff incubator was 37 6° C and the duration of incubation 2 hr The rather wide range of insulin-like activities in the pooled sera (Table 1) was probably due to the variability of whole batches of mice and to that of the test rats, the epididymal fat of which was used for the bioassay However, the bioassays of sera of obese and non-obese mice were always run in parallel, and with this in mind, the results of the comparisons between obese and non-obese animals within the framework of each series appear highly significant (Table 1)

Obese mice (except extremely aged animals) exhibited a higher circulating insulin-like activity than non-obese This relationship held for fasted as well as for fed mice Only in the ageing obese mice with high serum glucose was circulating insulin-like activity lower than in the non-obese animals of the same age

It thus appears that the increase in circulating insulin-like activity in the obese-hyperglycæmic mice previously postulated on the basis of increased insulin content and histological aspect of the pancreas has been confirmed[4] The hyperglycæmia in these animals is thus not due to a primary lack of insulin-like activity in the blood as is the case in totally depancreatized dogs and cats and probably in young diabetics who require insulin for survival It seems analogous to untreated obese maturity-onset diabetes without ketonuria, shown to be associated with near-normal concentrations of insulin in the pancreas and probably near-normal fasting insulin-like activity in the blood, increasing after oral glucose The results also suggest that ageing animals may show a transition from the obese-hyperglycæmic syndrome toward insulin depletion and that diabetes *per se* may be one of the causes of their premature death

This work was supported in part by grants-in-aid from the John A Hartford Memorial Fund, the National Institute of Arthritis and Metabolism (Gr No A-49), Public Health Service, Bethesda, the Albert and Mary Lasker Foundation, New York , the Nutrition Foundation, New York , and the Fund for Research and Teaching, Dept of Nutrition, Harvard We are grateful to Aelita Jurjevics for assistance

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* Holder of a research fellowship, supported in part by the International Co-operation Administration under a programme administered by the National Academy of Sciences

[1] Mayer, J , *Physiol Revs* **33**, 472 (1953)
[2] Mayer, J , *Nutr Abstr and Revs* , I, **25**, 597 , II, **25**, 871 (1955)
[3] Mayer, J , *Metabolism*, **6**, 435 (1957)
[4] Wrenshall, G A Andrus, S B , and Mayer, J , *Endocrinol* , **56**, 335 (1955)
[5] Martin, D B , Renold, A E , and Dagenais, Y M , *Lancet*, ii, 76 (1958)
[6] Winegrad, A I , and Renold, A E , *J Biol Chem* , **233**, 273 (1958)
[7] Mayer, J (to be published)
[8] Nelson, N , *J Biol Chem* , **153**, 375 (1944)

Effect of Polyphloretin Phosphate on the Suspension Stability of Red Blood Corpuscles

Polyphloretin phosphate belongs to a group of enzyme inhibitors of relatively high molecular weight synthesized a few years ago[1] By phosphorylation of phloretin—the aglucon of phlorizin—with phosphorus oxychloride under specific conditions a polymerization reaction occurred leading to a presumably cross-linked high-weight polymer

This compound, which does not dialyse through a 'Cellophane' membrane, has a strong electronegative charge and has been shown by ultracentrifugation to have a molecular weight of about

Table 1

Type of blood sample	Anticoagulant (*C*, sodium citrate, *H*, heparin)	Erythrocyte sedimentation rate									
		Amounts of polyphoretin phosphate in blood									
		None		0 5 mgm /ml		1 mgm /ml		1 5 mgm /ml		2 mgm /ml	
		½ hr	1 hr	½ hr	1 hr	½ hr	1 hr	½ hr	1 hr	½ hr	1 hr
Human (fracture)	*C*	—	98			15	32			0	0
,, (op pept ulcer)	*H*	50	87			28	81			0	0
,, (fractures)	*H*	115	118			95	115	4	20	0	0 5
,, (hepatitis)	*C*	50	92			4	9				
,, ,,	*C*	—	68	—	42			0	0		
,, (fracture)	*H*	—	122			35	70			0	0
Horse (normal)	*H*	60	92			11	87			2	3

25,000 It was soon discovered that polyphloretin phosphate was a very strong inhibitor of various enzymes, for example, hyaluronidase Further investigations have shown that polyphloretin phosphate has several biological effects[2,3] It decreases the permeability of serous membranes such as the peritoneum and the pleura, when employed locally Recently, a general effect on the capillary permeability was established as polyphloretin phosphate was effective in preventing experimental œdemas in rats and guinea pigs[4] Investigations concerning the eventual effect of polyphloretin phosphate on the œdema in experimental burns are going on[5] During this investigation it was noted that those animals, which had received polyphloretin phosphate, did not show any, or but a minimal, sedimentation of their red blood corpuscles, as distinct from the controls This effect gradually diminished but was again evident after a new intravenous injection of polyphloretin phosphate Numerous investigations have shown[6,7] that high erythrocyte sedimentation rate is the result of intravascular aggregation of erythrocytes

Preliminary studies *in vitro* of this disaggregating effect have shown that very small amounts of polyphloretin phosphate (0 1–0 3 per cent) added to the blood of human subjects with high erythrocytic sedimentation rates more or less totally reduces this (Table 1) Presumably this effect is connected with the negative electrical charge of polyphloretin phosphate The blood plasma, including the plasma coating on the surfaces of the red corpuscles, will be electrically charged, whereby the latter repel each other This observation, which will be further studied, may be of practical value as it is well known that many pathological conditions are associated with intravascular erythrocyte-aggregation which reduces the circulating red cell volume and thereby the oxygenation of various organs A practically serviceable disaggregating drug has long been looked for, and as polyphloretin phosphate has a low toxicity and is already in clinical use on other indications it is hoped that forthcoming investigations will prove it useful to combat intravascular aggregation in human subjects

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[1] Diczfalusy, E , Ferno, O , Fex, H , Hogberg, B , Linderot, T , and Rosenberg, T H , *Acta Chem Scand* , 7, 913 (1953)

[2] Fries, B , *Acta Chir Scand* , Supp , 217 (1956)

[3] Fries, B , and Walinder, G , *Acta Radiol* , 48, 113 (1957)

[4] Fries, B , *Acta Chir Scand* (in the press)

[5] Birke, G , Fries, B , Liljedahl, S -O , and Plantin, L E (unpublished)

[6] Fåhreus, R , *Acta Med Scand* , 55, 1 (1921)

[7] Knisely, M H , *et al* , *Science*, 106, 431 (1947)

A Rapid Method for studying Tumour Blood Supply using Systemic Dyes

THIS communication describes a method for making visible those regions of solid malignant tumours supplied with flowing blood, if necessary, within a few seconds We have found that the blood in the interior of many tumours is not in communication with the circulation, and that the only part of such tumours which receives flowing blood is a thin layer at the periphery, varying in thickness from a few millimetres to, in extreme cases, less than 0 1 mm

Numerous investigations of tumour vascularity have been made by the injection of various substances such as oil, indian ink and radio-opaque material[1,2] into the vessels However, all these produce physiological changes such as spasms in the vessels, they are laborious, and they are quite unsuitable for systemic use on the living animal. So far as these go, our present results are consistent with them A number of earlier workers have injected vital dyes for different purposes and recorded the late cellular uptake[2,3], but did not mention the immediate intravascular distribution of dye Our method uses a high concentration of the triphenylmethane dye lissamine green (Gurr , Soc Dyers and Colourists Colour Index No 737) in the blood, which remains deep green for about 1 hr and turns the whole animal green, except where there are barriers The dye appears to be non-toxic, and is eliminated in the urine and bile within 24 hr , and mice survived indefinitely after an intravenous injection of 20 mgm of the dye (1 ml of a 2 per cent dye solution in Ringer solution)—enough to give momentarily a blood concentration of 0 5 per cent and an average body concentration of 0 1 per cent in a 20-gm mouse Tests showed that the dye was not decolorized by the tumour Lissamine green was chosen because it had been previously found by Goldacre (unpublished work, 1955) not to penetrate the living cell membranes and to be particularly suitable as a test for death in individual cells, being less toxic than trypan blue It was hoped to mark out the necrotic regions of the tumour with this dye , if the dye reached all parts of the tumour the necrotic regions would become deeply stained, and the living regions unstained, as happens with the corresponding cell suspensions *in vitro* Instead, most of the tumours remained white, except for a green peripheral layer The surrounding tissues became green, due to the green blood in them and green interstitial fluid derived from the blood

The supposed superior vascularization of tumours over the surrounding tissues has been remarked on by many authors[4–9] The vigorous new vascular proliferation which occurs at the edge of rapidly growing tumours is eventually appropriated by the infiltrating tumour; what happens to the captured vessels is not always made clear, though Ide *et al.*[9] have observed, through a transparent window, a fading away of vessels in the tumour centre, and Ribbert[5], Apolant[6], Gierke[7], Goldman[1] and Ewing[10] remark that blood-filled cysts, cul-de-sacs, blood sinuses, aneurism-like structures and obstructive arterial changes are a feature of some tumours.

Table 1 shows the extent of the blood circulation in 73 tumours of various kinds, based on inspection of the dissected tumours a few minutes after 0.5 ml. of 2 per cent lissamine green solution had been injected into the tail vein of the mouse, or 1 hr. after 1 ml. had been injected intraperitoneally (for rats eight times as much of the dye solution was used); similar results were obtained with both methods. It appears that about 10–12 days following transplantation of the four types of tumour mentioned, that is, when the tumours are about 1–3 cm. across, vascular obstruction occurs, confining the flowing blood to a thin surface layer of the tumour. Extensive regions not supplied with flowing blood, with a thin coating layer supplied with blood, were also found in various large spontaneous and methylcholanthrene-induced tumours of indeterminate age. Throughout the remainder of such a tumour it was striking to find vessels containing bright red blood with microscopically intact red cells, though the blood in the rest of the body was green; if the tumour was cut across (when the mouse was kept alive under anæsthesia) it scarcely bled at all, except at the periphery. Also noteworthy is the well-known difficulty of washing blood out of tumours by perfusion. Similarly, dye injected into the centre of such a tumour was still present, sharply defined along the needle track, 24 hr. later, whereas if injected into muscle it was rapidly dispersed.

The only other parts of an injected mouse which were not green were the brain, the interior of the eye, the material on the fœtal side of the placenta (if the mouse was pregnant) and to a large extent the testis, ovary and adrenal gland. There did not seem to be a blood-tumour barrier comparable with the blood-brain barrier, since a similar distribution in the tumour was found whether the dye injected was a weak or strong acid or base, or uncharged, or had large or small molecules; but some, such as neutral red and methylene blue, entered the brain.

Table 1

Tumour	Age, in days, of tumours appearing in lissamine green test as		
	All green	Thick green periphery, small white centre	Thin green periphery, large white centre
Sarcoma 37	6	11, 14	12*, 12*, 18, 20*, 21*, 21, 25, 25, 32* *R*, 32 *R*, 33 *R*, 33, 42* *R*
Mammary carcinoma	6	10, 14, 14, 14, 15	13, 13, 13, 13* *R*, 14, 14, 14*, 14*, 14*, 14*, 15, 15, 15*, 15*, 18, 18, 19, 19, 20, 20, 20, 24, 34*, 42 *R*, 42 *R*
Ehrlich Landschutz	7, 8, 12, 12	6, 10, 12	11, 13*, 14*, 16, 18, 18, 18, 32, 32, 32, 36, 36
Walker (rats)		5†, 10, 10, 11, 13	7†, 11, 14, 14

* In these tumours the green region was less than 0.5 mm. thick over most of the surface (measured with the optical micrometer), that is, 16 out of 52 tumours in the appropriate age-group had only a paper-thin covering of tumour tissue with effective access to flowing blood. *R* indicates a regressing tumour.

† Rapidly growing Chester Beatty strain; the remaining Walker tumours were slower-growing transplants into a Stockholm strain of rats.

This vascular obstruction, affecting the bulk of each medium-sized and large malignant tumour, seems to have important bearings on tumour biochemistry and physiology. Previous ultra-violet absorption data[11], and more recent enzymatic observations on transplanted tumours[12], have shown that we have to consider two main types of cell: one is the young growing and multiplying cancer cell at the extreme periphery of solid tumours and tumour cords, the other is a much larger cell typical of central but still vital tumour zones. The latter is poor in cytoplasmic nucleic acids and also in enzymic activity, which perhaps to some extent could be due to oxygen deficiency and lack of nutrition. The observed regional heterogeneity of tumour cells together with the irregular vascular pattern of tumours will thus more or less affect the interpretation of biochemical and isotope-incorporation observations obtained at the usual macroscale. Further, it seems apparent that the lack of blood flow in the bulk of tumours may affect some attempts at immuno- and chemo-therapy of solid tumours. Tumour cells on the inner edge of the green region would be exposed to a lower concentration of antibodies and chemotherapeutic agents than the normal tissue cells. Cells dissected out from the non-coloured tumour region were found to be dead, since they were instantly stained with lissamine green, except when within about 300µ from the green region, where mixtures of living and dead cells were found. These implications will be discussed in a subsequent paper.

We wish to thank Prof. Alexander Haddow and Dr. L. Révész for kindly providing some tumour-bearing animals. The investigation has been supported by institutional grants from the Jubilee Fund of King Gustaf V, the Swedish Cancer Society, and the Jane Coffin Childs Memorial Fund.

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[1] Goldman, E. E., *Beitr. Klin. Chir.*, **72**, 1 (1911).

[2] Bellman, S., "Microangiography", Supp. 102 (*Acta Radiologica*, Stockholm, 1953).

[3] Ludford, R. J., Tenth Sci. Rep., Imperial Cancer Research Fund, 169 (1932). Foulds, L., *ibid.*, 191 (1932).

[4] Algire, G. H., and Chalkley, H. W., in "A Symposium on Mammary Tumours in Mice", Pub. No. 22, 55 (Amer. Assoc. Adv. Sci., Science Press, Lancaster, 1945).

[5] Ribbert, H., *Deutsch. Med. Wochenschr.*, **30**, 801 (1904). See also "Das Karzinom des Menschen" (Cohen, Bonn, 1911).

[6] Apolant, H., *Arb. a. d. Kon. Inst. Exp. Ther. Frankfurt am Main*, **1**, 7 (1906).

[7] Gierke, E., *Beitr. zur Pathol. Anat. u. allg. Path.*, **43**, 329 (1908).

[8] Thiersch, C., "Der Epithelialkrebs, namentlich der Haut. Eine anatomische clinische Untersuchung mit einem Atlas microbiologischer Abbildungen von 11 Tafeln" (Wilhelm Engelmann, Leipzig, 1865).

[9] Ide, A. G., Baker, N. H., and Warren, S. L., *Amer. J. Roentgenology*, **42**, 891 (1939).

[10] Ewing, J., "Neoplastic Diseases", 41 (Saunders, London, 1942).

[11] Caspersson, T., and Santesson, L., "Studies on Protein Metabolism in the Cells of Epithelial Tumours", Supp. 46 (*Acta Radiologica* Stockholm, 1943).

[12] Sylvén, B., and Malmgren, H., "The Histological Distribution of Proteinase and Peptidase Activity in Solid Tumor Transplants", Supp. 154 (*Acta Radiologica*, Stockholm, 1957).

Electron Microscopical Structure of the Wall of Small Blood Vessels in Human Multiform Glioblastoma

WHILE using the electron microscope to study the fine structure of the small vessels surrounding central necroses, typical of multiform glioblastoma, endothelial proliferation and the presence of processes arising from the 'basement membrane' were observed. The fine structure of the latter differed essentially from that in normal vessels. The present observations are in accordance with earlier light microscopical observations[1,2].

The material used consisted of four cases of multiform glioblastoma and three cases yielding tissue of origin, namely, normal brain tissue. Specimens were fixed in osmic acid, and embedded in methacrylate. Ultra-thin sections were examined with a Philips *EM* 100 *B* electron microscope.

The structure of the basement membrane of the blood vessels in multiform glioblastomas (Fig. 3) differed from normal basement membrane (Fig. 1) in that it exhibited considerable variations in thickness, which was in the range 300–2500 A., and had a relatively irregular outline forming numerous branches extending deeply into and between the endothelial cells. The laminar structure of the basement membrane of the capillaries was largely dissolved. The basement membrane of the venules and arterioles showed similar alterations. In the wall of the latter the collagen fibres appeared to be detached from the elastic framework, so that the whole elastica interna exhibited an extremely loose structure; at certain places the basement membrane was very thin and incomplete and the endothelium consequently stretched (Fig. 4).

The blood capillaries in multiform glioblastoma were generally characterized by a high degree of endothelial proliferation. The size of the nuclei and the amount of cytoplasm were increased (Fig. 2), as compared with capillaries of normal brain tissue. Furthermore, in some instances the lumen was completely filled with endothelial cells. The endothelial layers appeared to be continuous. Frequently the mitochondria in the endothelium were so densely packed that they were separated from each other only by thin membranes. The presence of processes with a layered structure in the endothelium and in part also between the endothelial cells was particularly striking where marked proliferation of the endothelial cells occurred, but less conspicuous elsewhere. The present findings seem to indicate that the intra-endothelial collagen does not originate in the endothelial cells, but in the external layers: the basement membrane or the elastica interna. The cells in the endothelial proliferation appeared to have lost their polarity. When the lumen became markedly narrow or totally occluded, the augmented pressure in the blood-vessel may have resulted in dilatation of the vessel on the proximal side of the occlusion, that is to say, on the side of the inflowing blood-stream, where the basement membrane or the elastica interna already was defective. This appears to be the mechanism in the development of irregularities and especially of the numerous small aneurysms characteristic of multiform glioblastomas.

Some of the cells in the pericapillary region were in intimate contact with the capillary walls through organelles resembling the Golgi apparatus. In these sites the basement membrane showed a more reticular structure. In close vicinity to the capillaries, between them and the necroses, numerous erythrocytes and lymphocytes with granular cytoplasm were seen, a finding often reported in conventional microscopic investigations of glioblastomas. In contrast to the capillaries in normal brain tissue, a large part of the capillaries of glioblastomas had a pericapillary zone of lower density.

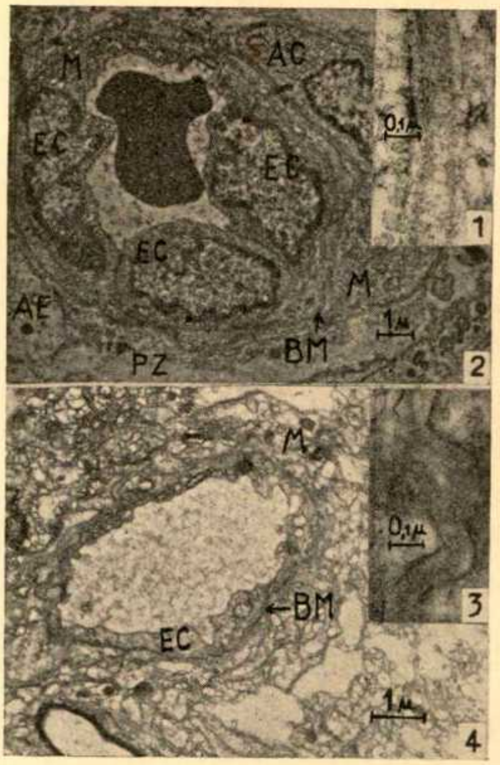

Fig. 1. Basement membrane (*BM*) of blood vessel in normal brain tissue. A longitudinal layer in the margins and a radially organized lamellar structure in the middle. × 45,000

Fig. 2. Hypertrophy and proliferation of endothelial cells (*EC*) in capillary wall of a glioblastoma. Pericapillary zone (*PZ*). Left: mitochondria (*M*) at the margin of an astrocytic end-foot (*AE*). Right: an 'additional cell' (*AC*). × 5,000

Fig. 3. *BM* of a capillary in a glioblastoma. Irregular outline and varying diameters. The structure is more vesicular than lamellar (cf. Fig. 1). × 45,000

Fig. 4. Capillary with an extremely thin and incompletely developed *BM*. × 7,400

The electron micrographs of normal vessels (controls) confirmed previous observations. In addition, the present findings of the structure of the normal basement membrane were corroborated by polarization microscopic observations[3].

Further results will be published later in another connexion, with special reference to the fine structure of the wall of the small vessels in other gliomas and in metastatic tumours.

This work was supported by a research grant from the University of Helsinki.

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[1] Deery, E. M., *Bull. Neurol. Inst. N.Y.*, **2**, 157 (1932).

[2] Zülch, K. J., and Christensen, E., "Handbuch der Neurochirurgie", **3** (Springer Verlag, Berlin, 1936).

[3] Niessing, K., and Rollhäuser, H., *Z. Zellforsch.*, **39**, 431 (1954).

Potentiation of Contractions after Rest in the Isolated Rat Ventricle Preparation

Post-rest potentiation describes the transient increase in the amplitude of contractions which occurs after a short period of rest in heart muscle.

This communication describes factors which influence the production of this augmented response in the electrically stimulated rat ventricle preparation; particularly some variations of the ionic composition of the medium.

The degree of potentiation was determined by measuring the amplitude of the first augmented response after the rest period, and expressing this as a percentage of the amplitude of the steady-state contractions (12/min.) preceding the rest period. Many modifications of the basic medium[1] were made, some of which necessitated changes in total ionic strength. Tonicity, however, was controlled with sucrose.

The degree of potentiation was found to increase when the rest period between two contractions was increased (see Fig. 1). This finding is in accord with the decrease of the contraction amplitude in response to an increase of the stimulation frequency. It follows that the steepness of the 'negative staircase' is proportional to the frequency after the rest pause.

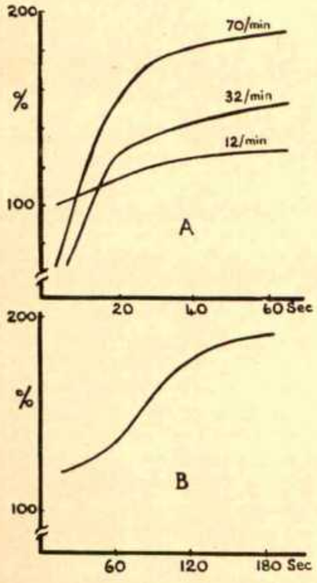


Fig. 1. Graphs plotting the degree of post-stimulation potentiation against: (*A*) duration of rest period; three frequencies of stimulation during the 2-min. conditioning periods are compared; (*B*) duration of the conditioning or 'work' period; stimulation frequency, 70/min. during the conditioning period; rest pause, 1 min.

An augmented contraction response followed by contractions of decreasing amplitude was produced after rest at all temperatures over the range 22–38° C. (compare Katzung and Farah[2]). A reversal of the 'staircase effect' could not be produced after rest by varying the temperature or by varying the calcium concentration. This is in contrast to the findings in turtle heart[2] and frog heart[3].

Conditioning periods of increased activity have been reported to alter the degree of potentiation[4]. This relationship between previous activity and potentiation has been confirmed (Fig. 1). The degree of potentiation after a rest pause has been found to be related to (*a*) the duration of the rest pause, (*b*) the frequency of stimulation preceding the rest pause, and (*c*) the duration of the period of stimulation preceding the rest pause.

Table 1

Medium	Effect on steady-state contractions (per cent)	Effect on potentiated contractions
8·8 m*M* KCl	+ 20	slight increase*
10·0 m*M* KCl	none	none
2·95 m*M* KCl	−20 to −35	slight decrease* (in contrast to increase noted by Penna and Garb (ref. 5))
7·8 m*M* $CaCl_2$	up to + 90	marked decrease or abolition
1·3 m*M* $CaCl_2$	−60	slight increase* (confirms Penna and Garb (ref. 5))
180 m*M* Na^+	−25 to −35	slight increase*
93 m*M* Na^+	+ 40	decrease or abolition (see Fig. 2)
80 m*M* Na^+	none	abolition

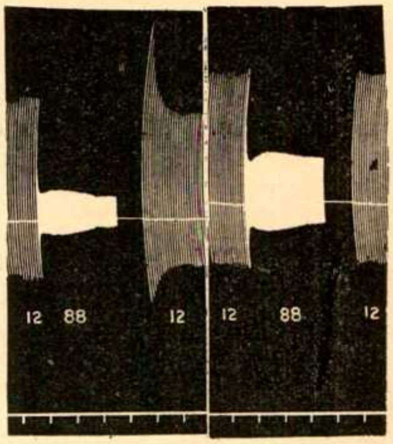
* Differences between potentiation in Krebs's medium and in experimental medium not statistically significant.

In contrast to several reports, it was found that a single extra systole or premature contraction did not induce further potentiation after a rest pause. These contradictory findings might be explained by variations in the composition of the media.

Analysis of the isometric twitches occurring during the 'negative staircase' suggests that prolongation of the active state is not the cause of potentiation after rest in the rat ventricle preparation. Acetylcholine, eserine and atropine were without effect upon both potentiated and steady-state contractions.

The influence of ions upon the potentiation of contractions is summarized in Table 1. Although decreasing the sodium or increasing the calcium concentrations in the medium produces an increase in the amplitude of steady-state contractions of heart muscle, it has now been shown that such ionic alterations also markedly reduce or even abolish the potentiation of contractions after rest. This finding lends support to the view that "the augmentation process differs fundamentally from the regular contractile process"[5].

The experimental results support the suggestion that the accumulation of a hypothetical 'potentiating



145 m*M* Na^+ 93 m*M* Na^+

Fig. 2. Records showing the absence of post-stimulation potentiation in 'low NaCl' medium. Stimulation frequencies per min. during conditioning periods are marked. Time intervals, 1 min.

substance' (hexose monophosphate[6] or noradrenaline[7]) is responsible for potentiation of contractions[2,4]. Since ionic changes are known to occur and remain for some time within muscle cells as a consequence of increased activity, these might influence cellular metabolism at the enzyme level or might act at specific sites on the cell membrane, and thus bring about, either directly or indirectly, potentiation of contractions. In the presence of a reduced external concentration of sodium or increased calcium, the ionic conditions necessary for the production of the potentiation are not present.

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[1] Krebs, H. A., and Henseleit, K., *Hoppe-Seyl. Z.*, **210**, 33 (1932).
[2] Katzung, B., and Farah, A., *Amer. J. Physiol.*, **181**, 557 (1956).
[3] Niedergerke, R., *J. Physiol.*, **134**, 569 (1956).
[4] Rosin, H., and Farah, A., *Amer. J. Physiol.*, **180**, 75 (1955).
[5] Penna, M., and Garb, S., *Amer. J. Physiol.*, **184**, 572 (1956).
[6] Ellis, S., *J. Pharmacol.*, **113**, 17 (1955).
[7] Whalen, W. J., Fishman, N., and Erickson, R., *Amer. J. Physiol.*, **194**, 573 (1958).

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Positive Inotropic Activity of Cytidine Triphosphate

Although nucleotides other than those of adenyl origin have been isolated from muscle[1], physiologists, when considering the events associated with the contraction-relaxation cycle, have assigned a dominant role to the adenosine derivatives—in particular to adenosine triphosphate[2]. It was therefore interesting to note that cytidine triphosphate exerted a marked positive inotropic action on isolated perfused toad hearts.

A perfusion apparatus and experimental technique, developed to record continuously the metabolic and physiological changes associated with drug action on the spontaneously beating toad heart (*Bufo marinus*), have been described previously[3]. In this study the apparatus was used without modification and the observations described were obtained from a series of eight hearts perfused at 25·0° C. before and following the addition of cytidine triphosphate (sodium salt) to give a final concentration of 10 µgm./ml. The gaseous medium was oxygen, and observations of beat-rate, drops per beat, maximum aortic pressure and rate of oxygen uptake were recorded at 15-min. intervals, except during that period immediately following the addition of cytidine triphosphate, when 3-min. observations were made.

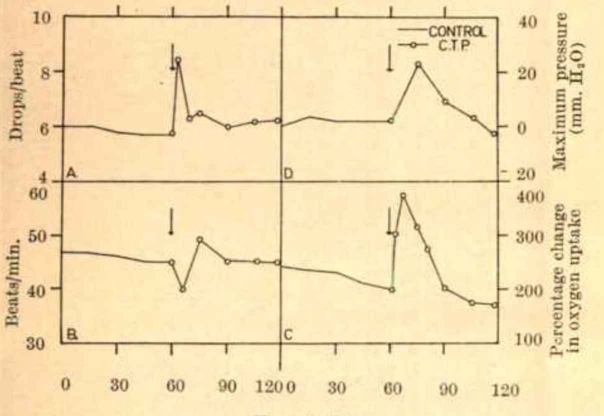


Fig. 1. Effect of cytidine triphosphate (10 µgm./ml. final concentration) on drops ejected per beat (1*A*), beats per min. (1*B*), maximum aortic pressure (1*C*) and oxygen uptake (1*D*) of the isolated heart. Mean results of eight experiments are displayed and cytidine triphosphate added at the arrow

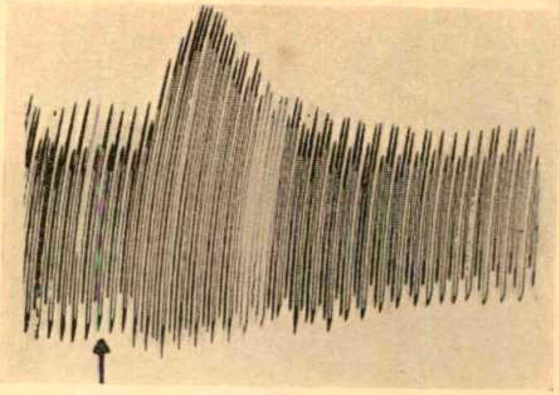
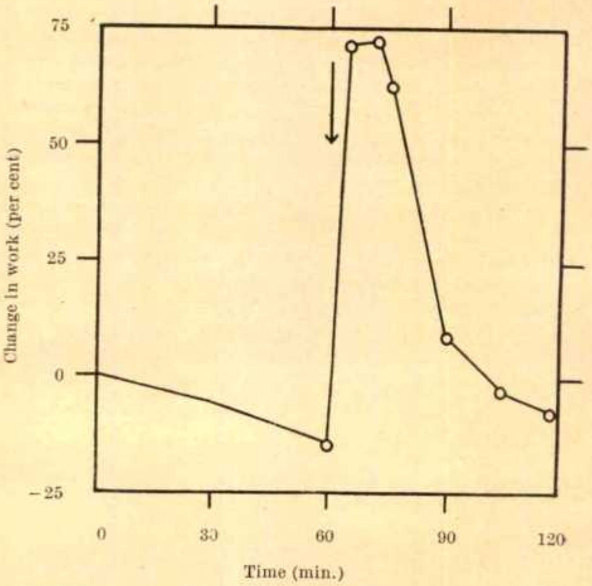


Fig. 2. Kymograph record showing positive inotropic effect of cytidine triphosphate (10 µgm./ml. final concentration)

The results obtained are summarized in Figs. 1–4. In Fig. 1 it can be seen that cytidine triphosphate at the above concentration produced an increase in the number of drops per beat (Fig. 1*A*) which was associated with a raised maximum aortic pressure (Fig. 1*C*) and an augmented rate of oxidative metabolism (Fig. 1*D*). A transient bradycardia, followed by a slight tachycardia, accompanied these changes (Fig. 1*B*).

The increased maximum aortic pressure noted was paralleled by an augmented force of ventricular



———, Control; —○—, cytidine triphosphate

Fig. 3. Mean results of eight experiments showing effect of cytidine triphosphate (final concentration, 10 µgm./ml.) on useful work done by the heart. Cytidine triphosphate added at arrow

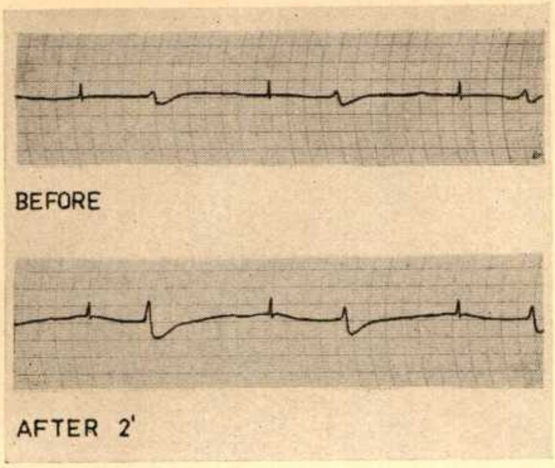


Fig. 4. Electrocardiograph tracing from perfused heart immediately before and 2 min. after addition of cytidine triphosphate (10 μgm./ml.). Note change in '*ST*' segment

contraction recorded by the conventional kymograph method (Fig. 2).

Correlation of the results shown in Fig. 1 provides an index of the useful work done by the heart, and in Fig. 3 it can be seen that cytidine triphosphate significantly increased this work-output-level.

In general, the positive inotropic effect of cytidine triphosphate described above resembles that previously recorded following the addition of glycosides and 9-α-fluorohydrocortisone to similar preparations[4,5]), for both involve increased work output levels associated with augmented rates of oxidative metabolism. This similarity raises the question as to whether nucleotides other than those of adenyl derivation are involved in the positive inotropic action of cardiac glycosides and whether or not these other nucleotides may play a part in the transfer of energy during normal contraction and relaxation.

The rapidity with which the effects of cytidine triphosphate appear and the deformation of the '*ST*' segment of the electrocardiograph which accompanies the response (Fig. 4) indicate the probability that surface activity is involved. Such a site of action may be linked with Kirschner's suggestion that phospholipids play a part in regulating ionic exchange rates across cell membranes[6,7], since cytidine-containing compounds are involved in the synthesis of phospholipids.

The expenses of this investigation were defrayed by a grant from the Life Insurance Medical Research Fund of Australia and New Zealand.

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[1] Burdette, W. J., *Amer. Heart J.*, **54**, 746 (1957).
[2] Szent-Györgyi, A., *New York Acad. Med. Bull.*, **28**, 3 (1952).
[3] Nayler, W. G., and McKelvie, D., *Aust. J. Exp. Biol. and Med. Sci.*, **34**, 239 (1956).
[4] Nayler, W. G., *Aust. J. Exp. Biol. and Med. Sci.*, **34**, 377 (1956).
[5] Nayler, W. G., *Aust. J. Exp. Biol. and Med. Sci.*, **35**, 241 (1957).
[6] Kirschner, L. B., *Arch. Biochem. and Biophys.*, **68**, 499 (1957).
[7] Kirschner, L. B., *J. Gen. Physiol.*, **42**, 231 (1958).

An Inhibitor of Cytochrome Oxidase Activity in the Sea Urchin Egg

Previous work in this laboratory[1,2] has demonstrated the presence of a highly active cytochrome oxidase in the isolated mitochondria of unfertilized sea urchin eggs. This activity is only 25 per cent lower than that of the mitochondria of the newly fertilized egg and up to the blastula stage[2]. No cytochrome oxidase activity has been found other than in the mitochondria[1,3]. On the other hand, it is known that the oxygen consumption of the unfertilized sea urchin egg is quite low; fertilization restores a normal respiratory level which increases continuously during the early development (for a discussion, see ref. 4). The suggestion was then made[2] that in the unfertilized egg an extra-mitochondrial respiratory inhibitor might be present which would be removed somehow upon fertilization.

In this communication we wish to report the results of experiments indicating the presence of an inhibitor of the cytochrome oxidase activity in the unfertilized egg.

Homogenates in sucrose or 0·01 *M* phosphate at *p*H 5·0 of unfertilized and fertilized jelly-free eggs of *Paracentrotus lividus* (freshly collected or lyophilized) were centrifuged at 12,000*g* for 10 min.; the supernatant was then centrifuged at 105,000*g* for 60 min. The inhibitory activity of the supernatant (called 'cytoplasmic supernatant') was assayed in a system as indicated in the legend of Fig. 1. Mitochondria were prepared from sucrose homogenates of unfertilized and fertilized eggs or from rat or mouse liver as described previously[2,5]. Since the inhibitory effect was manifested equally well on either sea urchin or mammalian mitochondria, the latter were then used routinely in our assays in order to have a more constant system. The cytochrome oxidase was assayed in a conventional Warburg apparatus[1,2].

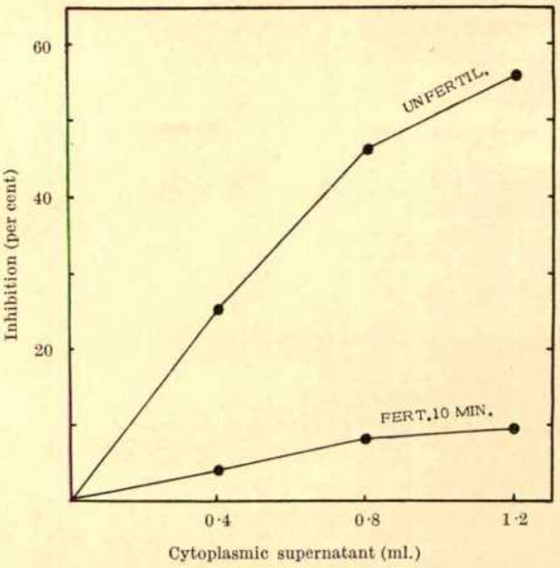

Fig. 1. Inhibitory effect of the cytoplasmic supernatant of unfertilized and fertilized eggs of *Paracentrotus lividus* on the cytochrome oxidase activity of mouse liver mitochondria. Each vessel contained in the final volume of 3·0 ml.: 0·2 ml. of mitochondria suspension; $2 \cdot 46 \times 10^{-5}$ *M* cytochrome *c*; 30 μ*M* sodium ascorbate; 0·033 *M* phosphate buffer *p*H 7·4; 0·2 *M* sucrose; cytoplasmic supernatant as indicated (in the present experiment both supernatants had a concentration of 1·35 mgm./nitrogen/ml.). Controls with cytoplasmic supernatant of mouse liver

Fig. 1 shows the striking inhibitory effect on the cytochrome oxidase activity of the cytoplasmic supernatant of unfertilized eggs, whereas in that prepared from eggs collected 10 min. after fertilization the inhibitory effect is much lower. In the cytoplasmic supernatant of eggs prepared 1 hr. after fertilization the inhibitory activity is negligible. After dialysis, the inhibitor has been quantitatively recovered in the dialysate (after concentration by lyophilization) thus indicating a low molecular compound. The inhibitor is quite stable in the acid-range (and, in fact, can be extracted fully active by 5 per cent trichloracetic or perchloric acid), whereas it is destroyed by alkalinization. The activity is almost completely abolished also by heating at 95° C. for 30 min. A preliminary purification of the inhibitor has been achieved by passing the crude concentrated dialysate at neutral pH through a 'Dowex 50' column in the ammonium-cycle. The inhibitor is thus quantitatively recovered in the effluent still contaminated by a few amino-acids but free of substances absorbing in the ultra-violet range between 250 and 280 mμ.

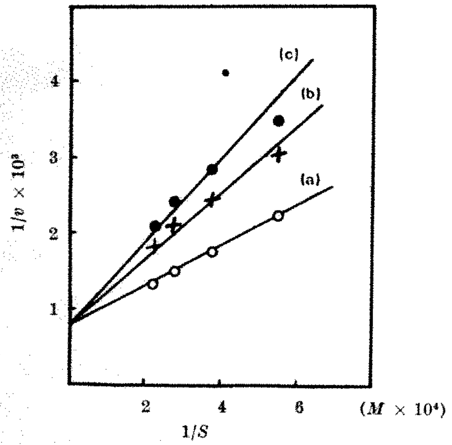

Fig. 2. A Lineweaver and Burk plot of $1/v$ (v, μl. oxygen/hr./mgm. protein) against $1/S$ (S, concentration of cytochrome c)). a, Control; b, with 0·25 ml. of inhibitor; c, with 0·5 ml. of inhibitor prepared as described in the text. Other conditions as in Fig. 1

Using this partially purified fraction we have obtained evidence for the competitive type of the inhibition, as is indicated in Fig. 2. Furthermore, spectrophotometric assays using isolated mitochondrial membranes[6] as a source of cytochrome oxidase suggest that the inhibitory action may affect the cytochrome oxidase itself. Work is in progress aiming at the identification and isolation of the inhibitor and examination of the process of its inactivation following fertilization.

This work has been supported by grants from the Rockefeller Foundation and the Consiglio Nazionale delle Ricerche.

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[1] Maggio, R., and Ghiretti-Magaldi, A., *Exp. Cell Res.*, **15**, 95 (1958).
[2] Maggio, R., *Exp. Cell Res.*, **16**, 272 (1959).
[3] Rapoport, S., Hofmann, E. C. G., and Ghiretti-Magaldi, A., *Experientia*, **14**, 169 (1958).
[4] Lord Rothschild, "Fertilization" (Methuen, 1956).
[5] Monroy, A., *J. Cell. Comp. Physiol.*, **50**, 73 (1957).
[6] Watson, M. L., and Siekevitz, P., *J. Biophys. Biochem. Cytol.*, **2**, 639 (1956). Siekevitz, P., and Watson, M. L., *ibid.*, **2**, 653 (1956).

Extended Dormancy of Deciduous Woody Plants treated in Autumn with Gibberellic Acid

WEAVER[1] has shown that autumnal application of gibberellin prolongs dormancy of *Vitis vinifera* shoots in the following spring. We[2] recently reported that application of gibberellic acid in late summer and autumn delayed leaf-fall of several woody species; further observations on these plants this spring have shown that in many of them dormancy was prolonged. Thus this unexpected response to gibberellins may not be uncommon.

In our experiments gibberellic acid was sprayed on as a 50 μgm./ml. aqueous soution. Fifteen weekly applications were made between mid-August and late November, 1958. Little or no after-effect was noticed when growth recommenced this spring in the following species: *Acer rubrum, Castanea sativa, Parthenocissus tricuspidata,* a *Rhododendron* × *molle* cultivar, *Taxodium distichum* and *Ulmus procera.* This list includes nearly all those species which showed no response in autumn to the gibberellic acid treatment but, in addition, two species where leaf-fall was delayed (*P. tricuspidata* and the *Rhododendron* hybrid) and the one species in which leaf-fall was accelerated (*T. distichum*).

Bud-break was delayed by 1–3 weeks in the following species: *Acer pseudoplatanus, Betula verrucosa, Fagus sylvatica, Fraxinus excelsior* and *Sorbus aucuparia.* Many buds and branch-tips of *B. verrucosa* were killed; we believe that this was due to frost damage of young growth induced by gibberellic acid in the previous autumn. In *Liriodendron tulipifera,* bud-break was more or less simultaneous on treated and untreated branches, but leaf-expansion was much slower on the treated branches.

The most striking effects were seen on *Prunus avium.* Here gibberellic acid had little effect on purely vegetative buds, but flower buds were profoundly affected. Most flower buds have remained completely dormant—indeed many are dead. Others have produced distorted or much-reduced flower clusters several weeks after untreated branches had flowered. On branches on the edge of the sprayed area, which probably received reduced doses of gibberellic acid as spray drift, flowering was delayed by about three weeks, though the flowers formed were in all other ways normal.

Of the species showing prolonged dormancy, one (*F. sylvatica*) showed no response to gibberellic acid in the previous autumn. Thus prolongation of dormancy is not necessarily a consequence of, or associated with, delayed onset of dormancy in the autumn. These results support Weaver's view[1] that properly chosen treatments with gibberellin in the autumn might usefully be employed to delay flowering in the following spring, in areas where frost damage is a hazard of fruit cultivation.

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[1] Weaver, R., *Nature*, **183**, 1198 (1959).
[2] Brian, P. W., Petty, J. H. P., and Richmond, P. T., *Nature*, **183**, 58 (1959).

BIOLOGY

A Suspected Virus Disease of the Citrus Red Mite *Panonychus citri* (McG.)

A DISEASED condition of the citrus red mite, *Panonychus citri* (McG.), was first observed in material collected dear Oxnard, California, in 1958. Experimental proof that the disease was transmissible was obtained by two methods: first, by transferring healthy mites to lemons bearing a diseased culture, and secondly, by spraying an aqueous suspension, prepared from ground-up diseased mites, on to healthy mite colonies. In each case the healthy mites developed infection[1]. Many diseased mites become paralysed with the legs stiffened ventrally. Diarrhœa sometimes occurs and mites may be found dead with the anal end fixed to the feeding surface by fæcal material.

Since no disease agent visible by optical methods could be detected, an intensive study with the electron microscope was made on the assumption that a virus might be concerned.

At first, ultra-thin sections of diseased and healthy mites were examined without any conclusive results. The next attempt was to try to isolate a virus; aqueous suspensions of diseased mites were made and clarified by differential centrifugation, the final spins being made at 36,000 r.p.m. (110,000*g*) on a 'Spinco' centrifuge. From three separate suspensions of material which had proved infective, a characteristic, virus-like particle was observed. The results obtained from a similar suspension of healthy mites, treated in the same way, were quite different. Whereas in the case of the infective fluid, virus-like particles were present in large numbers in every grid square, suggesting at a rough calculation 5 million particles/ml., it took several hours of hard searching to find three or four similar particles in the control fluid. This may suggest the presence of a small quantity of latent virus infection in the healthy mites. In a second control suspension no virus particles could be observed.

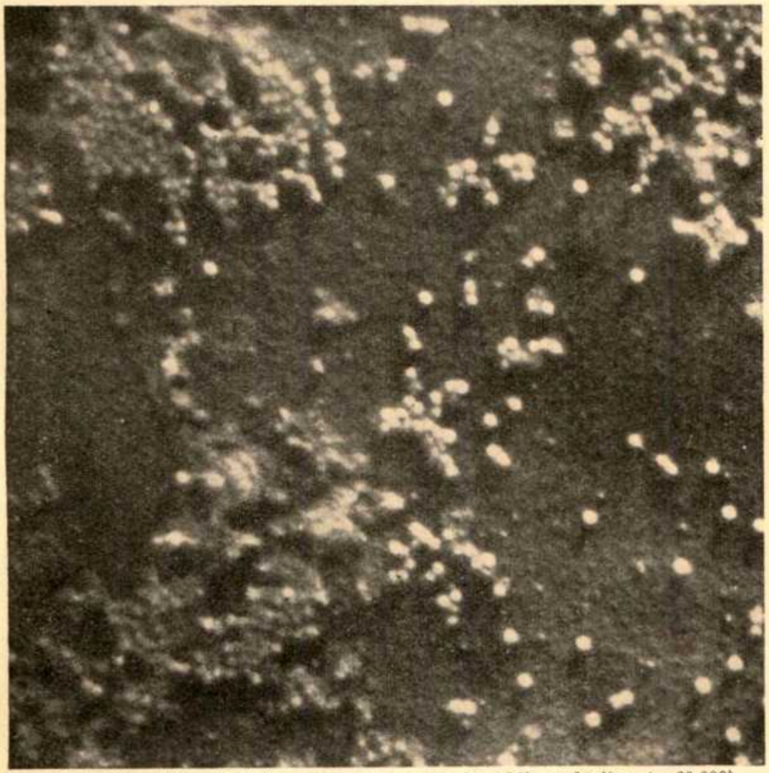

Fig. 1. Virus-like particles from an aqueous suspension of diseased mites. (× 60,000)

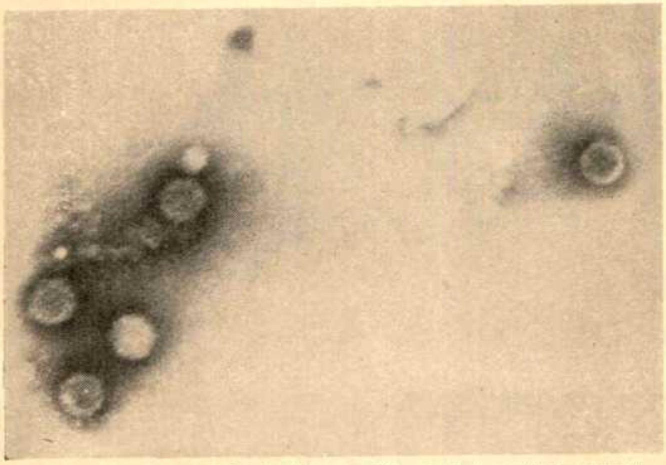

Fig. 2. Similar particles to those in Fig. 1, but negatively stained with phosphotungstic acid, adjusted to *p*H 7. The particles have a six-sided contour which suggests they may be icosahedra. The particles showing a darker centre are partially empty. (× 160,000)

Fig. 1 is an electron micrograph of the particles, shadowed with palladium gold; the particle is very small and measures about 35 millimicrons in diameter. The magnification is × 60,000. Fig. 2 shows similar particles stained with phosphotungstic acid at a magnification of × 160,000. Note the six-sided contour[2] and that four of the particles appear to be empty or partly empty[3].

This is the first record, so far as we are aware, of a virus disease in the Arachnida, and it suggests that viruses exist in other classes of organisms in which none has yet been discovered. That this disease might prove useful in the control of a serious citrus pest has already been indicated[1]. Whether it can be induced to attack other species of red spider (spider mites) in the United States or in Britain remains to be proved.

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[1] Munger, F., Gilmore, J. E., and Davis, W. S., *Calif. Citrograph.*, **44** (6), 190, 216 (1959).

[2] Williams, R. C., and Smith, K. M., *Biochim. Biophys. Acta*, **28**, 464 (1958).

[3] Smith, K. M., *Parasitology*, **48**, 459 (1958).

Stomach Contents of Spawning Quinnat Salmon

QUINNAT salmon (*Oncorhynchus tschawytscha*) normally spend up to a year after hatching in fresh water before migrating to sea as smolt. They stay at sea until mature, in three to four years time, then they usually cease feeding and migrate up the rivers to their spawning grounds. Quinnat salmon are reported to spawn once only, dying without feeding again after spawning.

On May 5, 1957, I assisted in the examination of some spawning quinnat salmon in the Harrison Bight Stream, a tributary of Lake Heron, New Zealand. L. Heron contains 'landlocked' quinnat salmon, but is also accessible to sea-run fish. Forty-three fish were examined, of which only four had anything in their stomachs. Of these four, one had some of the aquatic plant, *Potamogeton*, in its fore-stomach and the other three had each a young quinnat salmon.

The three which contained fish were spent dead males of 9½, 10 and 10¾ lb. weight. The lengths of the young quinnat salmon after preservation in formalin were 5·3, 6·3 and 6·9 in. These young fish were all males with hypertrophied testes, as shown in Fig. 1. There was little sign of digestion; two were slightly decomposed or digested in the head region, otherwise the skins were intact.

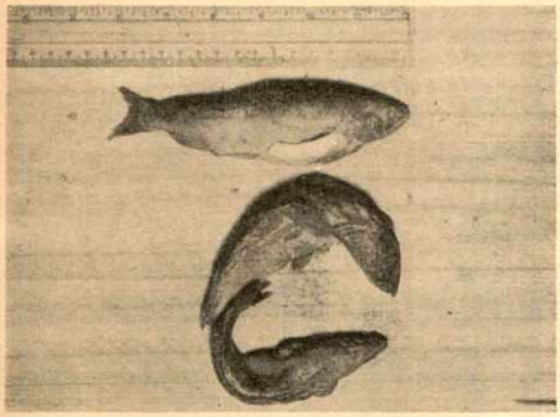

Fig. 1. Young quinnat salmon taken from stomachs of spawning quinnat salmon. Body-wall of top fish removed to show hypertrophied testes

One of the young quinnat salmon contained ten quinnat salmon eggs in its stomach, the others contained insect remains.

Dominance and hierarchy formation have been observed in groups of most salmonids[1]. Movements involved in feeding and in aggressive nipping by quinnat salmon are almost identical[2]. Also it is known that vigorous chasing between quinnat salmon occurs on the spawning redds. Hence, it is suggested that the young quinnat salmon were swallowed while being chased away from the redds by the larger fish.

The fact that the young fish appeared to have been feeding normally suggests that fasting and sexual maturity are not necessarily concomitant in male quinnat salmon.

Thanks are due to Prof. E. Percival for his advice.

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[1] Stringer, G. E., and Hoar, W. S., *Canad. J. Zool.*, **33**, 148 (1955).

[2] Bullivant, J. S., thesis, University of Canterbury, N.Z. (1958).

Local Races in Lugworms (*Arenicola marina* (L.))

THE spawning of *Arenicola marina* (L.) on the shores of the British Isles occurs during the last three months of the year, but within these limits there are striking variations of spawning time from place to place. Each local population of lugworms appears to have a characteristic spawning period which occurs at much the same time every year (Duncan, *Proc. Zool. Soc.*, in the press). The differences in the dates of spawning may indicate a tendency towards genetic variation between different populations; they would also encourage such differentiation. There are, of course, environmental differences between beaches which may influence the time of spawning, but it is difficult in this way both to account for the observed similarity of the spawning periods of lugworms at Dale Fort, Wales, and Whitstable, Kent, and for the fortnight's difference in the spawning of worms living as close together as Port St. Mary and Derbyhaven in the Isle of Man.

Lugworms are sedentary animals which spend most of their lives in their burrows. They are capable of swimming, and previous records of lugworms seen or caught in the sea[1] or of beaches emptied of lugworms being re-populated in a short time[2,3] suggest that they carry out migrations, particularly in winter[4], away from the colder, higher-lying parts of the beach and in the spring[5] which may be a dispersal movement. Such journeys are likely to be confined to their own or adjacent beaches unless there are strong tidal currents along the coast flowing close inshore. The fertilized egg sinks in sea water and the larva lives on the surface of the sand attached to sand grains; there are therefore no special provisions for widespread dispersal. Lugworms are not restricted to the littoral, but how far seawards they extend is not known. Often a change from sandy to rocky terrain limits the seaward distribution, but where a sandy bottom links two apparently separated sandy shores, it is possible that a sub-littoral stock may connect the two populations, and it appears likely that the lugworms of the British Isles exist in many nearly isolated populations, with only slight possibilities of interbreeding. Such a situation is clearly conducive to producing differentiated local races. It may therefore be of interest to note the following differences between populations in characters other than spawning period, which were observed in the course of my work.

The mean sizes of the spawning adults from different populations are given in Table 1 and show a very wide range, that for Llanfairfechan being eight times greater than that for Cullercoats. The spawning samples also showed considerable differences in their colour (Table 1). Apart from a tendency to darken with increase in size and age, the causes of these colour differences, whether environmental, physiological or genetical, are not known. There is a very small difference in the size of ripe cœlomic germ cells from lugworms of different localities (Table 1). The difference appears to be a real one, particularly for the oocytes (90 per cent of the healthy oocytes from ripe females from Port St. Mary were 170μ in diameter and only 5 per cent either 180μ or 190μ). There is no correlation between the mean size of the worms and the size their germ cells usually attain, as one would expect to find if availability of food in different beaches was a determining factor. There appear to be differences in the age and size at which *Arenicola*

Table 1. THE MOST FREQUENT SIZE OF RIPE COELOMIC GERM CELLS, MEAN SIZE OF WORMS AND PROPORTIONS OF THREE COLOUR PHASES IN FOURTEEN BRITISH POPULATIONS OF *Arenicola marina* IN 1951

	Size of oocytes (μ)*	Size of sperm plates (μ)*	Mean size of adult worms (cm.^{3})	Percentage of coloured worms : Light red	Dark red	Black
Llanfairfechan	180–190	80–100	8·3	23	31	46
Belfast	—	—	7·6	5	71	24
St. Andrews	180	80	6·5	74	26	0
Whitstable	170	110	6·0	20	62	18
Dale Fort	180	80	5·2	87	12	1
Rum Bay	170	80	4·9	11	18	71
Aberffraw	180	80	4·6	44	45	11
Millbrook	—	—	4·4	4	25	71
Millport	170	80	4·1	33	42	25
Derbyhaven	170	80	3·3	27	54	19
Port Erin	—	—	3·0	55	30	15
Port St. Mary	170	80–90	2·0	25	64	11
Strandhall	—	—	1·8	23	51	26
Cullercoats	—	—	1·1	90	4	6
Whitstable (Newell, 1948)	190	—	—	—	—	—
Lancashire (Ashworth, 1904)	150	80	—	—	—	—

* The worms containing these germ cells were collected just before spawning and were preserved in 4 per cent formalin, so that the measurements are comparable.

larvæ from different localities attain certain stages in their development (Table 2). On the whole, larvæ from Kent and the Isle of Man take longer to attain each developmental stage and there is variation in the sizes of larvæ at the same stage in development. The initial size of the ripe oocyte perhaps influences the size of the developing larva. Moreover, there was a small anatomical difference : all larvæ from the Isle of Man older than 10 days after fertilization possessed a prototroch with both long and short cilia, whereas these cilia are of uniform length in Blegvad's and Newell's figures of Danish and Kentish larvæ.

The evidence just presented is perhaps not impressive as evidence for the existence of local races in *A. marina*. The differences in size of ripe germ cells in different populations is very small, the sizes and ages of Danish larvæ and those from the Isle of Man are based upon animals reared in the laboratory and not under normal conditions, and the effects of environmental factors such as availability and nature of food upon the size and colour of lugworms have not been studied. There are, however, other differences among various populations which may be significant. Wells[6] examined 94 anomalous specimens of *A. marina* collected by Ashworth between 1908 and 1930 from two widely separated localities, the Firth of Forth and the Firth of Clyde, and found considerable variation in several structural features ; in fact the structural variation was such that he states that "characters which distinguish *Arenicola glacialis* from typical *A. marina* appear to be such as might turn up in anomalous *A. marina*". He therefore proposes that *A. glacialis* be given subspecific status as *A. marina glacialis* Murdoch. For comparison, Wells examined in 1956 samples of the present-day populations of lugworms from these two localities, and found that about 4 per cent of the worms from the Firth of Clyde showed anomalies in segment number and about 20 per cent of the worms from the Firth of Forth showed reduction in the annulation between not only the second and third chætigerous segments but also between the third and fourth. Such reduced annulation of the anterior segments was also found in some of the littoral populations examined during the present work although in much smaller proportions (ref. 6, p. 403). Such structural differences, if genetic, would be likely to appear among populations isolated geographically and with different breeding periods.

Table 2. A COMPARISON OF THE AGES (IN DAYS AFTER FERTILIZATION) AND LENGTHS (IN MM.) OF FOUR LARVAL STAGES OF *Arenicola marina* IN DIFFERENT LOCALITIES

Larval stage	Nyborg, Denmark, (ref. 7)	Whitstable, Kent (refs. 3 and 8)	Danish Flats (ref. 9)	Isle of Man
Ciliated larva	4th day (—)	4th day (0·24)	— (—)	7th day (0·17)
First chaet. segment	6th day (—)	— (—)	— (—)	15th day (0·29)
Second chaet. segment	8th day (—)	14th day (0·25)	— (—)	20th day (0·30)
Third chaet. segment	11th day (0·248)	3 weeks (0·33)	— (0·4)	— (—)

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[1] Meek, A., and Storrow, B., *Ann. Mag. Nat. Hist.*, **9**, 14 (1924).
[2] Thamdrup, H. M., *Medd. Komm. Havundersøg., Kbh.*, **10**, 2, 1 (1935).
[3] Newell, G. E., *J. Mar. Biol. Assoc. U.K.*, **27**, 584 (1948).
[4] Werner, B., *Helgoland wiss. Meeresunters.*, **5**, 93 and 359 (1954).
[5] Chapman, G., and Newell, G. E., *J. Mar. Biol. Assoc. U.K.*, **28**, 627 (1949).
[6] Wells, G. P., *Proc. Zool. Soc., Lond.*, **129**, 397 (1957).
[7] Blegvad, H., *Vidensk. Medd. dansk. naturh. Foren. Kbh.*, **76**, 1 (1923).
[8] Newell, G. E., *J. Mar. Biol. Assoc. U.K.*, **28**, 635 (1949).
[9] Smidt, E. L. B., *Medd. Komm. Havundersøg. Kbh.*, **11**, 6 (1951).

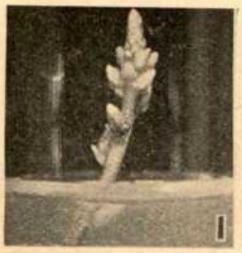
In vitro Culture of the Inflorescences, Flowers and Ovaries of an Apomict, *Aerva tomentosa* Forsk.

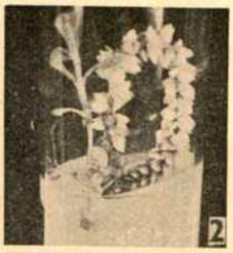
IN recent years several attempts have been made to culture the ovules[1] and ovaries[2] of some angiosperms. While there has been considerable success in raising viable seeds in test-tubes from normally fertilized ovaries[3], the results have not been so encouraging when unfertilized ovules[1,4] or ovaries are cultured. The present communication outlines the results of my experiments on an apomictic species, *Aerva tomentosa*[5].

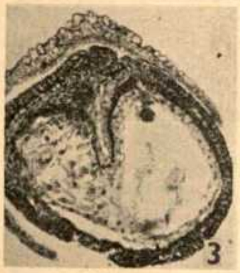
The plant is dioecious and male plants are extremely rare in Nature. The female flower possesses 5–8 perianth lobes enclosing a monocarpellary ovary and 8–10 staminodes.

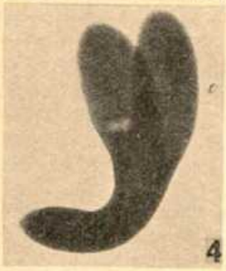
Three types of cultures were maintained : excised ovaries, flowers, and pieces of spikes. Nitsch's[6] medium was used with sucrose as a carbon source. This was also supplemented with vitamins and various growth substances.

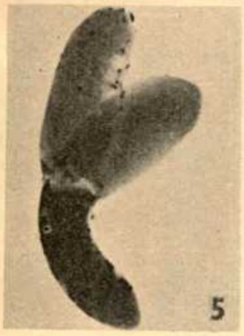
Ovaries (220μ in diameter) cultured at the megaspore mother cell stage in the basic medium yielded 20 per cent fruits. However, the fruits were smaller, being only 550μ in diameter as compared to the normal diameter of 1,100μ, and the seeds were abortive. Larger ovaries at the megaspore mother cell stage having a diameter of 440μ gave 40 per cent fruit set, but again the seeds were empty. On supplementing the basic medium with vitamins and glycine (supplemented medium) the fruit set increased to 50 per cent and the size was comparable to that attained *in vivo* (1,100μ), but only the seed coat developed normally and an embryo was absent. Gibberellin (10 p.p.m.) and indoleacetic acid (2 p.p.m.) either alone or in combination inhibited the growth of the ovaries and no fruits were obtained. In the supplemented medium to which kinetin (0·2 p.p.m.) and indoleacetic acid (2 p.p.m.) had been added, the











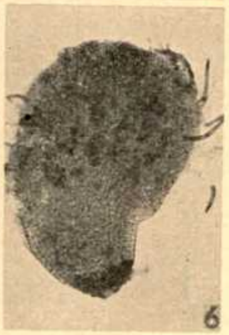


Fig. 1. Young spike after 3 days in supplemented medium + kinetin (0·2 p.p.m.) + indoleacetic acid (2 p.p.m.). No seeds were formed in such spikes. (× 0·7)

Fig. 2. Spike with open flowers inoculated in supplemented medium + yeast extract (500 p.p.m.) and photographed after 4 weeks. Seeds matured in many ovaries; one of the seeds has germinated *in situ*. (× 0·7)

Fig. 3. Longitudinal section of ovule showing globular embryo produced in 2 weeks from an open flower cultured on supplemented medium + yeast extract (1,000 p.p.m.). (× 32)

Fig. 4. Mature embryo from a flower attached to the plant; 2 weeks after the mature embryo sac stage. (× 18)

Fig. 5. An embryo dissected from a 4-week old spike inoculated at the mature embryo sac stage in supplemented medium (sucrose, 8 per cent). (× 21)

Fig. 6. A 4-week old embryo in supplemented medium + casein hydrolysate (200 p.p.m.) from a flower inoculated at the mature embryo sac stage. (× 20)

growth of the ovaries ceased after attaining a diameter of 550μ and the ovules failed to form the black seed coat.

In subsequent experiments ovaries were excised from open flowers (that is, at the mature embryo sac stage). When these were planted on supplemented medium and yeast extract (500 and 1,000 p.p.m.), a proembryo was formed; in very rare cases it developed up to the globular stage.

When whole flowers were cultured on supplemented medium, supplemented medium and yeast extract (1,000 p.p.m.) or supplemented medium and casein hydrolysate (200, 400 p.p.m.), 60 per cent of the ovaries grew into fruits; and 25 per cent of them gave viable seeds in about three weeks. In yeast extract (1,000 p.p.m.) a globular proembryo (Fig. 3) was formed in two weeks which took another week to mature. It was smaller than the embryos obtained from Nature which matured in only two weeks (Fig. 4). In supplemented medium and casein hydrolysate (200 p.p.m.) growth of the hypocotyl was arrested and the cotyledons were flap-like with numerous hairs (Fig. 6).

Next I attempted to rear young spikes (Fig. 1), but they never grew to maturity. However, spikes cultured at the time of the opening of flowers gave very encouraging results. Four concentrations of sucrose (2, 4, 6 and 8 per cent) were tried along with the supplemented medium. In these there was 40 per cent seed setting and the embryo was as large as or larger than that of plants growing in Nature (Fig. 5). With yeast extract (500, 1,000 p.p.m.) seed setting increased to 50 per cent but the embryo was slightly smaller than that of the controls. Occasionally these seeds germinated *in situ* (Fig. 2).

In *Aerva tomentosa* it has thus been possible to secure the normal growth of the embryo by culturing unpollinated flowers and spikes at the mature embryo sac stage. When the ovaries alone are cultured, the response is less satisfactory. Further work is in progress to promote the growth of excised ovaries and to rear normal seeds from closed buds.

I am greatly indebted to Prof. P. Maheshwari, under whose guidance this research was carried out. My thanks are also due to Dr. R. C. Sachar for help and interest and to Dr. L. G. Nickell, Chas. Pfizer and Co., New York, for gibberellin.

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[1] Sachar, R. C., and Kapoor, Manju, *Naturwiss.*, **22**, 552 (1958).
[2] Maheshwari, Nirmala, and Lal, M., *Nature*, **181**, 631 (1958).
[3] Sachar, R. C., and Kanta, Kusum, *Phytomorphol.*, **8**, 202 (1958).
[4] Maheshwari, Nirmala, *Science*, **127**, 342 (1958).
[5] Sachar, R. C., and Murgai, Prem, *Curr. Sci.*, **27**, 105 (1958).
[6] Nitsch, J. P., *Amer. J. Bot.*, **38**, 566 (1951).

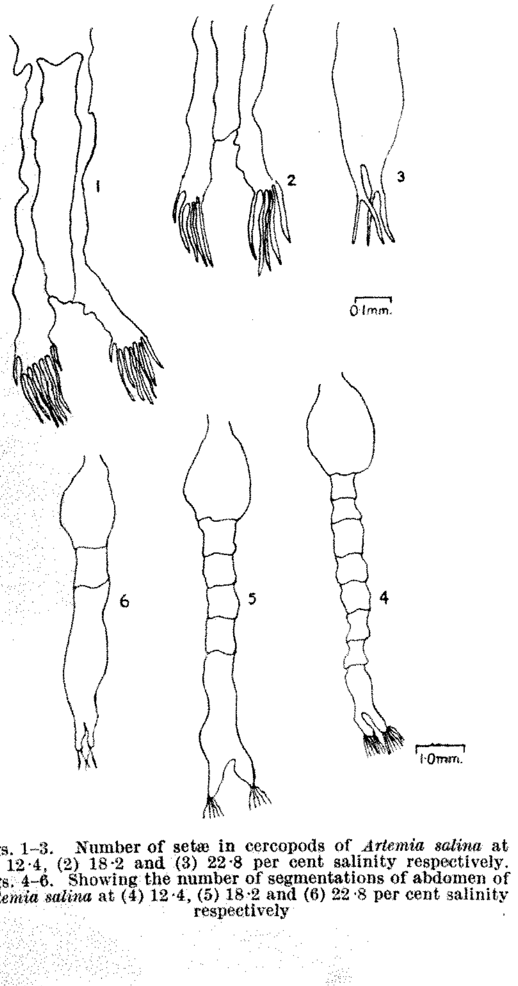
Occurrence of Neoteny in the Genus *Artemia*

THE genus *Artemia* has attracted the interest of many zoologists since the classic observations and experiments of Schmankewitsch[1]. This interest has been renewed by the occasional reconsideration of Schmankewitsch's observations and more rarely by the actual re-examination of *Artemia* species under different salt concentration of the water. Anikin, Samter and Heymons, Artom, Aboyni, and Gajewski have reported[2] morphological variations in response to change in salinity of the medium. But Martin and Wibur and Bond have reported[3] that *Artemias* from the Monterey Bay salterns and the coastal region of central California remain unchanged in different concentration of salt water. The *Artemias* which have shown variations in response to environment have all been Old World in origin, and it appears that no variable *Artemia* occurs in the western United States. The occurrence of *Artemia* from the oriental region was reported by Bond[4] from Tso-kar Lake, Tibet, Kulkarni[5] from Valda pans at Bombay and by Baid[6] from the Sambhar Salt Lake, Rajasthan.

The collection of *Artemia* from the Sambhar lake was brought to the laboratory in April 1957. Some *Artemias* were put in a higher concentration of salt water (18·4 per cent sodium chloride), where they underwent changes in size and in some morphological characters. All of them became small in size and differed considerably from *Artemia salina*. These dwarf *Artemias* were more or less identical with

A. milhauseni. They were actively reproducing in a higher concentration of salt water (22·8 per cent) as well as in lower concentrations (21·4, 16·5 and 8·5 per cent); I watched them for three generations in the laboratory. The experiments were repeated twice, with the same results. It is therefore clear that *A. milhauseni* cannot be reared back into *A. salina* as reported by Schmankewitsch[1]. The probable interpretation of these preliminary results is that *A. salina* of the Sambhar lake is a neotenous form of *A. milhauseni*. To test the variability in this genus and this observation some experiments in the ponds of Jaswant College Botanical Garden, Jodhpur, were carried out.

The pond was filled with lake water. The salinity of the water was diluted by adding distilled water. At 5·6 per cent salinity *Artemia salina* (females) were transferred to the pond. Some of these *Artemias* were also kept in a small pond adjacent to the big pond, the salinity of which was kept more or less constant (5·6 per cent salinity). At intervals of 24 hr., the main pond water and the *Artemias* were studied in the laboratory. Due to the heat, water from the pond had evaporated and consequently the salinity was higher. Some *Artemias* with pond water at 12·4, 18·2 and 22·8 per cent salinity were removed and placed in different aquaria in water of the same salinity as that of the pond water from which they were taken. After saturation was reached, distilled water was added slowly to the pond. The salinity and *Artemias* at different stages were studied in both the ascending and the descending series of experiments.



Figs. 1–3. Number of setæ in cercopods of *Artemia salina* at (1) 12·4, (2) 18·2 and (3) 22·8 per cent salinity respectively. Figs. 4–6. Showing the number of segmentations of abdomen of *Artemia salina* at (4) 12·4, (5) 18·2 and (6) 22·8 per cent salinity respectively

Three well-defined stages during the ascending series of experiments were observed in the change of salinity as well as in the population of *Artemia*. The various measurements of the body as well as salinity are given in Table 1. It was found that *Artemia salina* from water of 5·6 per cent and 12·4 per cent salinity metamorphosed completely into *A. milhauseni* at 22·8 per cent salinity. The changes were observed in the size of the body, segmentation of the abdomen and in cercopods (Figs. 1–6). At 12·4, 18·2 and 22·8 per cent salinity, *Artemia* taken from the pond and transferred to different aquaria having water of the same salinity continued to breed. *Artemia salina* in the small pond (salinity 5·6 per cent approximately) survived without undergoing any structural change. After reaching saturation point (23·2 per cent salinity), the highly concentrated water was diluted with distilled water. *Artemia* individuals were examined at 21·4, 16·5 and 8·5 per cent salinity in that order. It was observed that they were more or less identical with *A. milhauseni* or *Artemia* of 22·8 per cent salinity.

Table 1. MEASUREMENTS OF DIFFERENT PARTS OF THE BODY OF *Artemia salina* IN DIFFERENT CONCENTRATIONS OF SALT WATER

Salinity (per cent)	Median length (mm.)	Abdomen (mm.)	Post abdomen (mm.)	No. of individuals examined	Abdomen median length	No. of segments in the abdomen
12·4	10·3	5·5	4·8	14	0·535	8
18·2	9·1	5·1	4·0	12	0·56	5
22·8	8·0	4·5	3·5	8	0·562	2

No change was observed in the form of *A. salina* up to 12·4 per cent salinity).

From these observations it is concluded that *A. salina* is a neotenous form which is completely metamorphosed into *A. milhauseni* when the concentration of salt in the water is raised to the saturation point. The variations in the genus *Artemia* as reported by earlier workers[1,2] are also explained if we assume that neoteny is common in this genus. The salt lakes of the Old World have different concentrations of sodium chloride, and in consequence *A. salina* differs from lake to lake. The early workers raised each form to the status of a new species; but I believe they are neotenous forms, which differ from each other due to the degree of metamorphosis that each has undergone. They metamorphose completely if the concentration of sodium chloride is raised to the saturation point.

The nature of their environment also suggests that these *Artemias* are neotenous forms. The Sambhar Salt Lake is very salty and only 2 ft. deep; in summer the lake bed is completely dry. Neotony is very common among animals when the environment is hostile; it occurs in populations living in an adverse environment where metamorphosis amounts to death. There is a high mortality-rate in the population of *Artemia* during February and March. They seem particularly weak at this phase of their life-history. Hence if conditions become so unfavourable that all metamorphosed individuals perish, it follows that the population must either become neotenous or die out, since only those individuals which can breed as larvæ have any hope of propagating their kind.

It is significant that *A. salina* which breed as larvæ have an advantage, for they are able to produce offspring sooner than *A. milhauseni*, which may not be able to breed in the unfavourable conditions existing in the Sambhar Lake. Thus *A. salina* of the Sambhar Lake is a neotenous form of *A. milhauseni*, and is well adapted to such hostile conditions.

My thanks are due to Dr. J. P. Harding, British Museum (Natural History), for suggestions, and to Dr. D. K. Mathur for his help and guidance.

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[1] Schmankewitsch, W. J., *Z. wiss. Zool.*, **25**, 103 (1875).

[2] Anikin (1898, quoted by Bond). Samter, M., and Heymons, R., *Abh. preuss. Akad. Wiss.*, **2**, 82 (1902). Artom, C., *Biologia* (Torino), **1**, 5 (1907). Aboyni, A., *Z. wiss. Zool.*, **114**, 38 (1915). Gajewski, N., *Int. Rev. ges. Hydro. u. Hydrogr.*, **10**, 139 (1922).

[3] Martin, E. G., and Wibur, B. C., *Amer. J. Physiol.*, **56**, 290 (1921). Bond, R. M., *Int. Rev. ges. Hydro. u. Hydrogr.*, **28**, 117 (1932).

[4] Bond, R. M., *Mem. Conn. Acad. Arts and Sci.*, **10**, 75 (1934).

[5] Kulkarni, C. V., *J. Bombay Nat. Hist. Soc.*, **51**, 951 (1953).

[6] Baid, I. C., *Curr. Sci.*, **27**, 58 (1958).

AGRICULTURE

Non-Symbiotic Nitrogen Fixation in a Soil of the Nigerian Rain-Forest Zone

COMPARATIVELY little is known of the contribution of non-symbiotic nitrogen fixation to the nitrogen economy of tropical soils. In the tropical rain-forest areas it is generally considered that the soil nitrogen supply, depleted by arable cropping, is built up again during the period of 'bush fallow', presumably by indigenous legumes (and perhaps certain non-legumes) present in the regrowth. That appreciable non-symbiotic nitrogen fixation may occur in the soils of this area was shown in the experiment described here.

A bulk sample was collected from the 0–20 cm. layer of Iwo loamy sand, a latosol developed over gneiss. This soil came from a cropped area on the Faculty of Agriculture Farm, University College, Ibadan. 3-kgm. lots were placed in pots in the greenhouse, and six cultural treatments and two fertilizer treatments applied. Total nitrogen (Kjeldahl plus nitrate) contents are shown in Table 1.

There were appreciable increases in the nitrogen content in the case of the bare soil and the soil to which glucose had been added, as well as a smaller increase in the soil on which *Centrosema* was grown. There was also a small but statistically significant increase in nitrogen when fertilizer containing phosphorus and molybdenum was added.

The increase in nitrogen recorded above for the bare soil is equivalent to approximately 140 lb. of nitrogen or 6 cwt. of ammonium sulphate per acre, an increase of considerable agricultural significance were it to occur in the field. It has been estimated that some 15 lb. of nitrogen per acre per annum are fixed in the soils of the Sudan Gezira, where crops of dura have been produced annually for centuries without the use of fertilizers or manures[1]. Under temperate conditions it has been estimated that legumes may fix 150–300 lb. and free-living nitrogen-fixing micro-organisms 15–30 lb. of nitrogen per acre per annum[2].

The growing of plants on the soil appears to have depressed nitrogen fixation (or to have increased denitrification). The nitrogen contained in the plant material (tops plus roots) amounted to approximately 0·05 gm. per pot for the legume (*Centrosema*) and 0·04 gm. per pot for the grass (*Eleusine*). Thus there was no net increase in nitrogen where the grass was grown, and the increase with the legume was only about half that found in the bare soil.

Since the soils of the rain-forest zone carry growing plants almost continuously (either 'bush fallow' or arable crops) it is unlikely that non-symbiotic nitrogen fixation is important agriculturally, even though the potential capacity for fixation by this means may be great. In most of the indigenous rotations of southern Nigeria the period during which the land is bare does not amount to more than a few months (the time between clearing and planting) in 5–10 years.

The results recorded here are nevertheless considered to be of sufficient interest for the study to be continued and expanded.

Table 1. TOTAL NITROGEN CONTENT OF THE UPPER 20 CM. OF IWO LOAMY SAND AS INFLUENCED BY DIFFERENT CULTURAL AND FERTILIZER TREATMENTS

Fertilizer treatment	Soil kept dry N (gm.)/pot	Soil kept moist for 20 weeks					
		Bare N (gm.)/pot	Bare + 30 gm. glucose per pot N (gm.)/pot	Mulched with wood shavings N (gm.)/pot	*Centrosema pubescens* grown N (gm.)/pot	*Eleusine coracana* grown N (gm.)/pot	Mean* N (gm.)/pot
No fertilizer	1·03	1·11	1·14	1·00	1·04	1·02	1·06
Plus phosphorus plus molybdenum	1·03	1·36	1·23	1·05	1·10	0·90	1·11
Mean†	1·03	1·24	1·18	1·02	1·07	0·96	

* Difference between means for fertilizer treatments is statistically significant ($P < 0·05$).
† Differences among means for cultural treatments are statistically significant ($P < 0·01$). *L.S.D.* = 0·06 gm. nitrogen per pot.

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[1] Crowther, E. M., "Agriculture in the Sudan", 459 (Oxford University Press, London, 1948).

[2] Russell, E. J., "Soil Conditions and Plant Growth", 310, 323 (Longmans, Green and Co., London, 1950).

Swellings on the Shoots of Cacao Plants Deficient in Copper

AN experiment to induce symptoms of micro-nutrient-element deficiency on cacao grown in sand-culture was undertaken in 1958. The sand and chemicals were purified as recommended by Hewitt[1] and the water was demineralized by passing it through resin columns. The treatments were done in duplicate; a complete set of treatments was randomized within each of two blocks. Seeds were taken from the centre portions of Amelonado cacao pods (where they are more uniform); they were washed and planted directly into the sand, three seeds to a plastic pot. The plants were watered with demineralized water twice a day for one week, after which 500 ml. of nutrient solution was supplied in the mornings and an equal amount of water in the afternoons. Complete overhead shade was given for one month, after which it was reduced to 50 per cent. Plants were harvested 100 days, 204 days and 321 days after sowing.

Table 1. DIAMETER OF COPPER-DEFICIENT SHOOTS IN THE SWOLLEN AREA OF STEM WHEN THE SWELLINGS WERE FIRST OBSERVED

Distance from tip (cm.)	Treatment without copper		Control	
	Plant *A*	Plant *B*	Plant *A*	Plant *B*
0	4·57	4·30	4·76	4·90
5	4·28	5·25	5·79	6·65
10	5·27	6·90	6·35	6·90
13		8·84*		
15	8·65	8·60	6·84	7·3
15·5	8·82*			
20	10·76	7·65	7·23	7·3
21	10·81*			

* Maximum diameter of swelling.

At 273 days after sowing the remaining plant in each of the two treatments without copper was showing severe leaf symptoms of copper deficiency. Several of the small, immature leaves had abscissed and internodes were short in the area of leaf abscission. Lateral buds were swelling and on plant *A* a strong lateral shoot, 19 cm. long, had arisen below the affected area. These morphological changes indicated a loss of dominance by the shoot tip.

It was at this stage that swellings were noticed on the main shoots of both plants in the treatment without copper, two on plant *A* and one on plant *B*. Measurements of shoot diameter taken on the same day are shown in Table 1. The swollen areas were from 1·5 mm. to 3·5 mm. larger than comparable positions on the control shoot.

During the ensuing 49 days before the plants were harvested there were more leaf flushes, all of which remained on the shoots and showed less evidence of copper deficiency. The shoot tip regained its dominance and no more lateral buds broke. Plant *A* grew 31·1 cm. and plant *B* grew 20·7 cm. during the last 49 days.

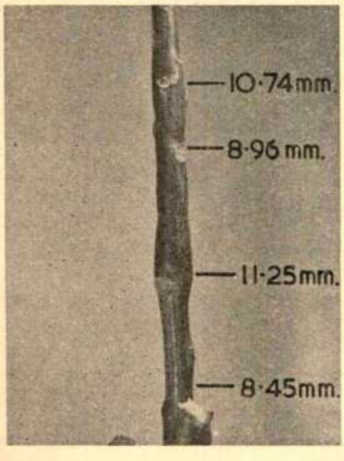

Fig. 1. The swollen area, at harvest, of shoot from plant *A*

Fig. 1 shows the two swellings on plant *A* at time of harvest when the swellings were 1·7 mm. and 2·8 mm. larger than the shoot diameters immediately below the swellings. Transverse sections through the swollen areas showed that the swellings were due primarily to increased xylem thickness.

It has been proved that swollen shoot disease of cacao in West Africa is caused by a virus[2,3]; this does not, however, rule out the possibility of a relationship between swollen shoot disease and copper deficiency.

The complete results of this experiment will be published elsewhere

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[1] Hewitt, E. J., "Sand and Water Culture Methods Used in the Study of Plant Nutrition" (Comm. Bureau Hort. Plant. Crops, 1952); Tech. Comm. No. 22 (Bradley and Sons, Ltd., Reading).

[2] Posnette, A. F., *Trop. Agric. Trin.*, **17**, 98 (1940).

[3] Thresh, J. M., W. African Cacao Res. Inst. Bull., No. 4, 1–36 (1958).

A Method of increasing the Phosphorus Content of Forages

IN connexion with the feeding of cattle, especially dairy cattle, phosphorus plays a very important part. Forages, the basic need of cattle, should contain as much phosphorus as possible in order to prevent serious pathological troubles.

Phosphate fertilizers are usually applied late in autumn or early in winter. However, it seems that another application of phosphate, in a water-soluble form, late in winter (February or March), considerably increases the phosphorus content of forages. But the efficiency of this second application of fertilizer is improved when nitrogen is associated with water-soluble phosphates (40 kgm./hectare (36 lb./acre) phosphoric acid and 40 kgm./hectare (36 lb./acre) nitrogen).

The results obtained in a series of experiments carried out in 1957 and 1958 on different farms, using several plots of the same paddock in each case, are shown in Table 1.

Table 1

Type of grassland	P and PK in autumn		P and PK in autumn, N late in winter		P and PK in autumn, N + P late in winter*	
	Content of forages		Content of forages		Content of forages	
	P (per cent)	Ca (per cent)	P (per cent)	Ca (per cent)	P (per cent)	Ca (per cent)
Temporary grassland (lucerne–cocksfoot)	0·25	1·01	0·37	1·17	0·39	0·93
Permanent grassland	0·20	1·07	0·22	0·68	0·24	0·67
,, ,,	0·19	0·65	0·21	0·85	0·25	0·89
,, ,,	0·29	0·71	0·24	0·55	0·33	0·70
,, ,,	0·22	1·02	0·24	0·95	0·30	0·95
,, ,,	0·28	0·48	0·32	0·49	0·34	0·57
Average	0·24	0·82	0·27	0·78	0·31	0·79
Ca/P average	3·34		2·89		2·51	

* The fertilizer dressing late in winter involved: 200 kgm./hectare (180 lb./acre), 20 per cent 'nitro-chalk', 200 kgm./hectare (180 lb./acre), 18 per cent superphosphate of lime.

It appears clearly from these figures that applications of nitrogen fertilizer late in winter have a considerable effect in increasing the phosphorus content of plants.

It looks as if a real 'shock' dressing was achieved. The nitrogen–phosphorus association seems to give rise to a synergy, quite favourable to the uptake of phosphorus. This quick absorption by plants reduces fixation of phosphate due to the 'holding power' of the soil. Nitrogen appeared to have an optimum effect when applied in the form of 'nitro-chalk'.

These preliminary results are very encouraging. If they were confirmed, they would help to solve the important problem of ensuring enough phosphate in the cattle ration, especially in that of dairy cows

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STATISTICS

A Least-Squares Solution for a Linear Relation between Two Observed Quantities

A linear relation has sometimes to be established between two observed quantities, the precision of each observed value for both quantities being limited and variable from value to value in some known way Examples in astronomy may be found in the treatment of proper motions in moving clusters, in the evaluation of solar motion by proper motions, and in the evaluation of the linear terms of galactic rotation in the solar neighbourhood In such cases the line through the intersection of the two regression lines, with a slope equal to the geometric mean of the slopes of the two regression lines, may often be a good estimate of the best linear relation, but it does not seem to be a least-squares solution in a precise sense Seares[1] discusses at length the best estimates of the regression lines that can be set up, taking into account varying weight for each value and the effect on the regression lines of the distribution of the observed values about the diagram His best linear relation is evaluated as the weighted geometric mean of the two regression lines and he shows[2] that in the case of uniform precision in each quantity his solution reduces to that obtained by Hertzsprung[3] to cover this particular case It would seem, however, that generalization of Hertzsprung's result to cases of varying precision should be possible without bringing in the regression lines at all Jeffreys[4] apparently gives such a solution (his equation 5, § 4 42), but in fact, as was pointed out to me by Dr A J Wesselink, his solution reduces to one of the usual regression lines in the case of uniform precision and not to Hertzsprung's solution Trumpler and Weaver[5] mention several times the importance of 'two-error' least squares solutions in astronomy but nowhere make a solution

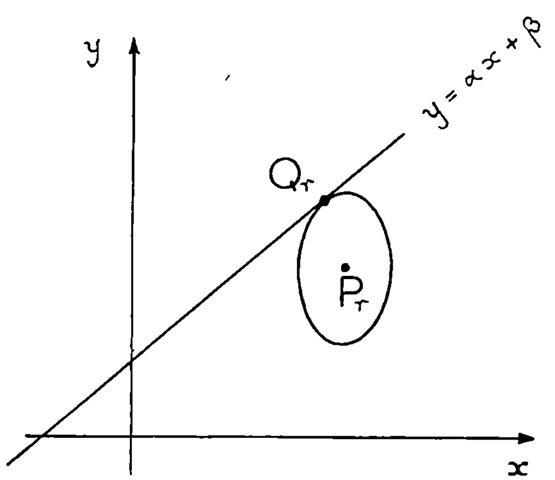

Fig 1

In the present approach we start with a geometric representation, though there are definite similarities to Jeffreys's procedure In Fig 1 P_r is a typical point representing a pair of observed values (x_r, y_r) and the line $y = \alpha x + \beta$ is a possible relation between 'true' values The point Q_r on this line is the point of contact of the tangential ellipse belonging to the set of similar concentric ellipses centred on P_r with equations

$$\frac{(x - x_r)^2}{s_r^2} + \frac{(y - y_r)^2}{t_r^2} = d_r^2 \qquad (1)$$

s_r^2 and t_r^2 are the variances for the precision with which the individual values x_r and y_r, respectively, are known Of all the points on the line $y = \alpha x + \beta$, Q_r, with co-ordinates (ξ_r, η_r), is the one that will give an observed pair of values (x_r, y_r) with maximum likelihood The appropriate value of d_r^2 in (1) for the tangential ellipse is found to be

$$\delta_r^2 = w_r(\alpha x_r - y_r + \beta)^2 \qquad (2)$$

where $w_r = 1/(t_r^2 + \alpha^2 s_r^2)$

This result is similar to that obtained from Jeffreys's expression[4] (§4 42) for the maximum logarithmic likelihood

$$\log L_{\max} = \text{constant} - S \frac{(y_r - \alpha x_r - \beta)^2}{2(t_r^2 + \alpha^2 s_r^2)}$$

that is, $\log(L_{\max}/L_0) \propto \delta_r^2 \qquad (3)$

If uniform prior probability of the α and β is assumed the least-squares condition in obtaining the best values of α and β for a set of observed values (x_r, y_r) is given by the equations ·

$$\frac{\partial}{\partial \alpha}(\prod_r L_{\max}) = 0 \text{ and } \frac{\partial}{\partial \beta}(\prod_r L_{\max}) = 0$$

Transforming to δ_r^2 by (3) we obtain

$$\left.\begin{aligned} \frac{\partial}{\partial \alpha}(\sum_r \delta_r^2) &= \sum_r \frac{\partial}{\partial \alpha}(\delta_r^2) = 0 \\ \text{and } \frac{\partial}{\partial \beta}(\sum_r \delta_r^2) &= \sum_r \frac{\partial}{c\beta}(\delta_r^2) = 0 \end{aligned}\right\} \qquad (4)$$

and the best values of α and β are the solutions of the equations

$$\beta \sum_r w_r = \sum_r y_r w_r - \alpha \sum_r x_r w_r \qquad (5)$$

and

$$\alpha^2 \sum_r w_r^2 s_r^2 x_r (y_r - \beta) + \alpha \left\{ \sum_r w_r^2 t_r^2 x r^2 - \sum_r w_r^2 s_r^2 (y - \beta)^2 \right\} - \sum_r w_r^2 t_r^2 x_r (y_r - \beta) = 0 \qquad (6)$$

The summations in (5) and (6) can only be made numerically if α is known Hence the practical solution is by a method of successive approximation, which will be rapidly convergent if a reasonably good value of α can first be derived graphically or otherwise

If $t_r = k s_r$ = constant, we readily obtain

$$\beta = \bar{y} - \alpha \bar{x}$$

where $(\bar{x}, \bar{y})$ are the arithmetic mean values of the (x_r, y_r) α is then the suitable root of the quadratic equation

$$(\alpha^2 - k^2) \sum_r (x_r - \bar{x})(y_r - \bar{y}) + \alpha \left\{ k^2 \sum_r (x_r - \bar{x})^2 - \sum_r (y_r - \bar{y})^2 \right\} = 0 \qquad (7)$$

This equation corresponds to Hertzsprung's solution, there being in practice no confusion between the two roots, one minimal and the other maximal In such cases the line passes through the 'centre of gravity' of the observed points This is only true for the solution of (5) if we regard the centre of gravity to be that found after applying a weight w_r to each point

Trumpler and Weaver[5] (p 184) say that in two-error solutions the parameter estimates depend upon the 'distribution of', in our notation, the (x_r,y_r) about the diagram In fact, Seares's solution was via regression lines from which the systematic effects associated with the distribution of the (x_r,y_r) had been removed and this is why the distribution entered into the argument Here, we proceed directly from a separate consideration of each point and it is only afterwards that, for example in (7), the marginal variances of the x_r and y_r distributions appear.

Some prior knowledge of the s_r and t_r is, of course, fundamental to a completely meaningful approach to the problem but useful applications of equations (5) and (6) are likely to occur where a problem can be put into the form of solving for the least-squares linear relation only at the expense of introducing widely varying precision for the different observed values of both quantities

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[1] Seares, F H , *Astrophys J* , 100, 255 (1944)

[2] Seares, F H , *Astrophys J* , 102, 366 (1945)

[3] Hertzsprung, E , Leiden Ann , XIV, Eerste Stuk (1922)

[4] Jeffreys, H , "Theory of Probability", 164 (Oxford University Press, 1939)

[5] Trumpler, R J , and Weaver, H F , "Statistical Astronomy" (Univ of California, 1953)

HISTORY OF SCIENCE

The Value of π and the Old Testament

Many recent authors of texts containing an account of the historical development of the numerical value of π write under the misapprehension that in the Old Testament its apparent value is 3 Concerning this value, Prof E T Bell writes[1] "This approximation to π is famous for its occurrence in the Old Testament" Quoting 2 Chron 4, 2, Prof L Hogben deduces[2] "The ancient Hebrews were content with taking π as 3" The late Prof G H Hardy could scarcely have examined his two quotations, otherwise he would not have made the blunt observation[3] "It is stated in the Bible that π = 3" P Dubreil quotes[4] 1 Kings 7, 23, and contrasts the approximation with Shanks's value of π to 707 decimal places Quoting 2 Chron 4, 2, Prof T Dantzig comments[5] that this description indicates that the Jews held that π is equal to three Very recently, Archbold quotes[6] Dubreil that the Bible gives the value of π as 3, thereby perpetuating the error in the minds of the next generation of students who read his text These writers therefore fall into two classes, the first regarding π as actually given by 3, and the second regarding the measurements given as only approximate Even some Biblical commentators have fallen into similar error , for example, Curtis and Madsen in their commentary[7] on 2 Chron 4, 2 suggest that the numbers are only approximations

A careful reading of the verses following 1 Kings 7, 23 is sufficient to dispose of this approximation, quite apart from consulting the works of those who have sought to restore the "molten sea" from the Biblical dimensions For it transpires that the circumference of 30 cubits and the diameter of 10 cubits do not refer to the same circle, so it is impossible to conclude that π was taken as 3, either mistakenly or approximately

The diameter of the "molten sea" at its extreme top from brim to brim was 10 cubits But in 1 Kings 7, 24, we must interpret "*under* the brim of it round about there were knops compassing it" The word 'under' may imply that the external surface of the brim need not have been vertical , the cylindrical sides of the "sea" were inclined outwards in order to form the brim, yielding a smaller circle around which the knops (gourds or wild cucumbers) were cast under the slightly larger circle formed by the brim This is confirmed by verse 26, where we read that "the brim was wrought like the brim of a cup, with flowers of lilies", for Sir W Smith's dictionary[8] interprets this as meaning that the brim was curved outwards like a lily or lotus flower, giving at the same time the literal translation of the Hebrew text "its lip was like work such as a cup's lip, a lily flower" The "30 cubits compassing the sea round about" (verse 23) refers then to the general circumference of the "sea" below the brim and not to the special circumference around the brim Thus the circumference of the brim must have been 10π cubits, and the diameter of the cylindrical wall of the "sea" below the brim must have been 30/π = 9 55 cubits , these irrational measurements are omitted from the text

Even the commentators have often missed this point Montgomery and Gehman[9] state that the dimensions are only round figures, thereby failing to see that there is nothing in the text (1 Kings 7, 23–26) that suggests that the figures 10 and 30 refer to the same circle, although their literal translation, "a lily-shaped brim", implies circles of varying diameters

These observations may be verified by noting that Sir W Smith's dictionary[8] gives a general sketch of the "sea" according to the restoration by Keil , a distinct outwardly curving brim exists, with the rows of knops underneath it A larger encyclopædia[10] gives a detailed etching of the restoration according to Calmet, together with a complete axial cross-section of the "sea" , this too shows the characteristic brim, with the rows of knops below it around a circle of smaller diameter than that of the brim

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[1] Bell, E T , "The Development of Mathematics", 40 (McGraw-Hill, New York, 1945)

[2] Hogben, L , "Mathematics for the Million", 251 (Allen and Unwin, London, 1940).

[3] Hardy, G H , "A Course of Pure Mathematics", 70 (Cambridge, 1952)

[4] Dubreil, P , "Les Grands Courants de la Pensée Mathématique", edit by le Lionnais, F , 99 (Cahiers du Sud, 1948)

[5] Dantzig, T , "Number, the Language of Science", 113 (Allen and Unwin, London, 1947)

[6] Archbold, J W , "Algebra", 5 (Pitman, London, 1958)

[7] Curtis, E L , and Madsen, A A , "The International Critical Commentary , The Books of Chronicles", 331 (Clark, Edinburgh, 1910)

[8] Smith, W , "A Dictionary of the Bible", 3, 1172 (Murray, London, 1893)

[9] Montgomery, J A , and Gehman, H S , "The International Critical Commentary , The Books of Kings", 173 (Clark, Edinburgh, 1951)

[10] Singer, I , "The Jewish Encyclopedia", 3, 357 (Funk and Wagnalls, New York, 1925)

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned

LECTURER IN THE DEPARTMENT OF VETERINARY PHARMACOLOGY—The Secretary, The University, Edinburgh (August 28)

SENIOR LECTURER (with an honours degree in metallurgy and a successful record of research work) IN METALLURGY—The Registrar, Royal Technical College, Salford 5, Lancs (August 29)

TECHNICAL OFFICER (with experience, including administration, in a Physiology or similar Department) IN PHYSIOLOGY at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (New Zealand, August 30)

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF VETERINARY PHARMACOLOGY—The Registrar, The University, Liverpool (August 31)

ASSISTANT LECTURER IN BIOCHEMISTRY—The Dean, Guy's Hospital Medical School, London Bridge, S E 1 (August 31)

LECTURER or ASSISTANT LECTURER (with some industrial and research experience) IN THE DEPARTMENT OF CHEMICAL ENGINEERING to specialize in separation processes, fluid dynamics or thermodynamics and chemical kinetics—The Registrar, The University, Leeds 2 (August 31)

RESEARCH ASSISTANT (with an honours degree in botany, with training in cytology and/or genetics) IN THE DEPARTMENT OF BOTANY, for duties mainly in the University Botanic Gardens, Ness, Cheshire—The Registrar, The University, Liverpool (August 31)

LECTURER IN MECHANICAL ENGINEERING—The Registrar, The University, Nottingham (September 5)

JUNIOR LECTURER IN MATHEMATICS—Prof E C Titchmarsh, Mathematical Institute, Oxford (September 14)

LECTURER (Grade I) IN RADIOLOGY at University College, Ibadan, Nigeria—The Secretary, Senate Committee for Colleges Overseas in Special Relation, University of London, Senate House, London, W C 1 (September 14)

LECTURER (with good qualifications in light current electrical engineering or in physics) IN ELECTRONIC ENGINEERING, and a LECTURER (with a thorough knowledge of the physics of materials, and preferably with research or industrial experience involving solid state physics) IN MATERIALS—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (September 14)

READER (graduate of a British Commonwealth university or equivalent, Corporate Member of the Institution of Electrical Engineers, with teaching and research experience at university level) IN ELECTRICAL ENGINEERING at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Hong Kong, September 15)

RESEARCH ASSISTANT (preferably with an interest in the ecology and systematics of small mammals) IN THE DEPARTMENT OF ZOOLOGY—The Secretary and Registrar, The University, Southampton (September 15)

SENIOR TUTORS (2) IN PURE MATHEMATICS at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, September 19)

ASSISTANT (with at least an honours degree in biochemistry or equivalent) IN BIOLOGICAL CHEMISTRY—The Secretary, The University, Aberdeen (September 21)

LECTURERS (2) (with experience either in infra-red spectroscopy or in radiochemistry) IN THE DEPARTMENT OF CHEMISTRY—The Deputy Registrar, The University, Edgbaston, Birmingham 15 (September 21)

READER, and a LECTURER IN PURE MATHEMATICS at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, September 25)

CHAIR OF PHARMACEUTICAL CHEMISTRY in the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, September 26)

CHAIR OF APPLIED MATHEMATICS in the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (South Africa, September 30)

LECTURER IN THEORETICAL PHYSICS in the Natural Philosophy Department—The Secretary, The University, Aberdeen (September 30)

LECTURER or an ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSIOLOGICAL CHEMISTRY, for duties chiefly concerned with the teaching of the physiology of domestic animals—The Registrar (Room 29 O R B), The University, Reading (September 30)

LECTURER (with qualifications in any of the branches of zoology, and preferably an interest in insect physiology or some other branch of experimental zoology) IN ZOOLOGY at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, September 30)

READER IN GENETICS in the Department of Zoology at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 1)

AGRICULTURAL CHEMIST (with a good honours degree in agricultural chemistry, and at least two years suitable postgraduate training or experience) in Sierra Leone to advise the Director of Agriculture on specific problems and for investigational studies in the field, including the laying out of field trials and their statistical analysis and interpretation—The Director of Recruitment, Colonial Office, London, S W 1, quoting BCD 63/15/04/T

CHAIR OF PHYSICS in the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 15)

CHEMIST (post-doctorate), to carry out a programme of exploratory research on a problem in synthetic aromatic chemistry—Dr P Holt, Department of Chemistry, The University, Reading

LECTURER IN INORGANIC CHEMISTRY at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W C 1

PHYSICIST or PHYSICAL CHEMIST (with a good honours degree or equivalent, in physics or physical chemistry, and some years research experience) WITH THE NATURAL RUBBER DEVELOPMENT BOARD, to work in a small team carrying out research on the use of natural rubber in road surfacing materials—The Director of Road Research, Road Research Laboratory, Harmondsworth, West Drayton, Middlesex, quoting "Natural Rubber Development Board"

RESEARCH ASSISTANT IN THE MATHEMATICS DEPARTMENT, to work with Prof H A Jahn and Dr J P Elliott on the theory of nuclear structure—The Registrar, The University, Southampton

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Government of Northern Ireland Ministry of Agriculture Leaflet No 133 Commercial Egg Production on Range Pp 8 (Belfast Ministry of Agriculture, 1959) [144

Report of the West African Timber Borer Research Unit, 1955–58 Pp 62+2 plates (London Crown Agents for Oversea Governments and Administrations, 1959 Published on behalf of the West African Timber Borer Research Unit) 5s [144

Illuminating Engineering Society Monograph No 1 Inter-reflection and Flux Distribution in Lighted Interiors Pp 11 (London Illuminating Engineering Society, 1959) 5*s* [144

Scottish Home Department Freshwater and Salmon Fisheries Research Series, No 23 Tenth Annual Report of the Supervisory Committee for Brown Trout Research, 1957–1958 Pp 15 (London H M Stationery Office, 1959) 4*s* 6*d* net [144

Royal College of Science and Technology, Glasgow Annual Report on the One Hundred and Sixty-second Session Pp 64 Report on Research, Session 1957–58 Pp 40 (Glasgow Royal College of Science and Technology, 1959) [144

In Britain Today By Thomas Kerfoot (Address to the (U S) Pharmaceutical Manufacturers' Association, Boca Raton, Florida, April 2nd 1959) Pp 20 (London Association of British Pharmaceutical Industry, 1959) [144

University of London University College Annual Report, 1957–1958 Pp 95 (London University College, 1959) [144

Wool Industries Research Association Report of the Director of Research for 1958 (W I R A Publication No 212) Pp 35 (Headingley, Leeds Wool Industries Research Association, 1959) [144

Government of Northern Ireland Ministry of Agriculture Leaflet No 127 Intensive Systems of Commercial Egg Production Pp 20 (Belfast Ministry of Agriculture, 1959) [144

Department of Scientific and Industrial Research Forest Products Research Bulletin No 44 Heat Penetration in the Pressing of Plywood By J F S Carruthers Pp iv+22 (London H M Stationery Office, 1959) 1*s* 9*d* net [144

University of Cambridge Report of the Observatories Syndicate for the year ending 1958 September 30 Pp 5 (Cambridge The University, 1959) [144

Perspective, Vol 1, No 1 (Quarterly Review of Progress in Photography, Cinematography, Sound and Image Recording) Pp 112 Annual subscription 52*s* 6*d* , 7 50 dollars , 30 D M , 30 Swiss francs, post free (London The Focal Press, Ltd , 1959) [144

Research Defence Society Conquest Pamphlet No 7 Surgery of the Heart and Circulation Outstanding questions posed and answered by the Research Defence Society Pp 4 6*d* Notes on the Law relating to Experiments on Animals in Great Britain Second edition Pp 16 1*s* 6*d* (London Research Defence Society, 1959) [144

Some Problems in the Breeding of Farm Livestock an Inaugural Lecture By Prof T L Bywater Pp ii+17 (Leeds The University Press, 1959) 2*s* 6*d* [144

Tetrahedron Letters, No 1 (March, 1959) (The International Organ for the rapid publication of preliminary communications on Organic Chemistry) Published every two to four weeks Pp 35 Subscription, post paid (air mail charges extra) (A) £7 (U S A 20 dollars) per annum, for Libraries, Government Departments and Industrial Establishments (B) No extra charge for private subscribers to *Tetrahedron* who write direct to the publisher certifying that the subscription is for their personal use (London and New York Pergamon Press, 1959) [144

Queen's University of Belfast The Pursuit of Knowledge a Collection of Essays on Current Research in the Queen's University of Belfast Pp 87 7*s* 6*d* Queen's a Short History of Queen's College, Belfast, and the Queen's University of Belfast Pp 10 6*d* (Belfast Queen's University, 1959) [144

Mammals By Edmund Seyd Pp 16 (Manchester The Museum, 1959) 2*s* [144

Manchester Literary and Philosophical Society Memoirs and Proceedings, Vol 100, 1958-59 Pp vi+98+11 plates (Manchester Manchester Literary and Philosophical Society, 1958) 21*s* [144

Discovery Reports, Vol 29 Octocorals Part 1 Pennatularians By Hjalmar Broch Pp 245–280+plates 11 and 12 17*s* 6*d* net The Foetal Growth Rates of Whales with special reference to the Fin Whale, *Balaenoptera physalus* Linn By R M Laws Pp 281–308 12*s* 6*d* net Distribution and Life History of *Euphausia triacantha* Holt and Tattersall By A de C Baker Pp 309–340 15*s* net (Cambridge At the University Press, 1958) [144

Scottish Marine Biological Association Collected Reprints for 1959 Reprints Nos 268–299 (Millport, Isle of Cumbrae Scottish Marine Biological Association, 1958) [144

Ministry of Agriculture, Fisheries and Food Bulletin No 180 Hybrid Chickens Pp iv+39 (London H M Stationery Office, 1959) 2*s* 6*d* net [144

An Account of the Birds of Stowe Pp 48 (Buckingham Biological Department, Stowe School, 1958) [144

Scottish Home Department Marine Research Series, 1959 No 1 Hydrography of the North-Western Approaches to the British Isles By D S Tulloch and Dr J B Tait Pp 32 10*s* net No 2 Hydrography of Scottish Coastal Waters By R E Craig Pp 30 10*s* net (London H M Stationery Office, 1959) [144

Other Countries

Occasional Papers of the Natural History Museum of Stanford University No 7 A New Frog of the Genus *Telmatobius* from Southern Ecuador By Harold E Munsterman and Alan E Leviton Pp ii+5 (Stanford, Calif Natural History Museum of Stanford University, 1959) [24

Transactions of the American Philosophical Society New Series, Vol 49, Part 1 The Spectrum of Beta Lyrae By J Sahade, A -S Huang, O Struve, and V Zebergs Pp 64 (30 plates) (Philadelphia American Philosophical Society, 1959) 2 dollars [144

The Discrete and the Diffuse in Nervous Action By David P C Lloyd (James Arthur Lecture on the Evolution of the Human Brain, 1958) Pp ii+28 (New York American Museum of Natural History, 1959) [144

British Guiana Geological Survey Bulletin No 31 A Brief Appraisal of Ground-Water Conditions and Proposed Program for Water Resources Investigations in the Coastal Artesian Basin of British Guiana By G F Worts, Jr Pp 52+1 plate (Georgetown Government Printer, 1958) 1 dollar 4*s* 2d [144

Publications de l'Institut National pour l'Etude Agronomique du Congo Belge Serie Scientifique No 77 Recherches sur les Affinities Chromosomiques dans le Genre *Coffea* Par J Bouharmont Pp 94+2 planches 70 francs No 78 Recherches sur l'Autosterilite du Caféier Robusta (*Coffea canephora* Pierre) Par M Devreux, G Vallaeys, P Pochet et Dr A Gilles Pp 44+8 planches 40 francs (Bruxelles Institut National pour l'Etude Agronomique du Congo Belge, 1959) [144

World Health Organization Technical Report Series No 152 Ataractic and Hallucinogenic Drugs in Psychiatry—Report of a Study Group Pp 72 2 Swiss francs, 3*s* 6*d* , 0 60 dollars No 156 Expert Committee on Training of Health Personnel in Health Education of the Public—Report Pp 40 1 Swiss franc, 1*s* 9*d* , 0 30 dollars (Geneva World Health Organization, London H M Stationery Office, 1959) [144

Commonwealth of Australia Sixth Annual Report of the Australian Atomic Energy Commission for the year ended 30th June, 1958 Pp 62 (Sydney Australian Atomic Energy Commission, 1959) [144

World Health Organization Technical Report Series No 163 Expert Committee on Auxiliary Dental Personnel—Report Pp 32 (Geneva World Health Organization, London H M Stationery Office, 1959) 1 Swiss franc, 1*s* 9*d* 0 30 dollars [144

Commonwealth Scientific and Industrial Research Organization Soil Publication No 13 Soil Features in Relation to Erosional History in the Vicinity of Canberra By D C van Dijk Pp 41 (Melbourne Commonwealth Scientific and Industrial Research Organization, 1959) [144

Bulletin of the Astronomical Institutes of the Netherlands Vol 14, No 488 (1958 December 31) A Survey of the Continuous Radiation from the Galactic System at a Frequency of 1390 Mc/s By G Westerhout Pp 215–263 Vol 14, No 489 (1959 February 14) Three Southern Open Clusters NGC 3532, 6475 (M7), and 6124 By D Koelbloed Pp 265–278 (Leiden Astronomical Institutes of the Netherlands, 1958 and 1959) [144

Colony on Mauritius Annual Report of the Mauritius Institute, 1956 Pp i+12 25 cents Annual Report of the Mauritius Institute, 1957 Pp i+17 25 cents (Port Louis Government Printer, 1957 and 1958) [174

Radiation a Tool for Industry (Talk by S Edward Eaton and Michael Michaelis of Arthur D Little, Inc , Cambridge, Massachusetts, before the 7th Annual Conference Atomic Energy in Industry, held by the National Industrial Conference Board, Inc , at Cleveland, Ohio, April 8–10, 1959) Pp i+28 (Cambridge, Mass Arthur D Little, Inc , 1959) [144

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Conseil Permanent International pour l'Exploration de la Mer, Charlottenlund Slot, Danemark Annales Biologiques, Vol No 14, 1957 Rédigé par A Fridriksson Pp 223 (Copenhague Andr Fred Høst & Fils, 1959) 40 Kr [144

Canada Department of Mines and Technical Surveys Annual Report for the Calendar Year 1957 Pp iv+142 (Ottawa Queen's Printer, 1959) 50 cents [144,

Fiskeridirektoratets Skrifter Serie Havundersøkelser (Report on Norwegian Fishery and Marine Investigations) Vol 12, No 3 Seasonal Changes in the Phytoplankton at Various Points Off the Norwegian West Coast By T Braarud, K Ringdal Gaarder and O Nordli Pp 77 (Bergen AS John Griegs Boktrykkeri, 1958) [144

University of Pennsylvania School of Medicine—Graduate School of Medicine *Medical Affairs*, Vol 1, No 1 (Spring, 1959) Pp 36 (Philadelphia *Medical Affairs*, 201 South 34th Street, 1959) [144

Annals of the New York Academy of Sciences Vol 72, Article 13 The Analysis of Mixtures of Volatile Substances By Emil F Williams and 44 other authors Pp 559–785 4 dollars Vol 79, Article 1 Quantum Aspects of Catalysis The Drying of Linseed Oil By Raymond R Myers Pp 1–8 50 cents (New York New York Academy of Sciences, 1959) [144

East Africa High Commission The East Africa High Commission Annual Report, 1958 Pp iv+92 (Nairobi Government Printer, 1959) Sh 5 [144

The Carlsberg Foundation's Oceanographical Expedition Round the World 1928–30 and Previous "Dana" Expeditions "Dana" Report No 46 The Hydromedisae of the Atlantic Ocean and Adjacent Waters By P L Kramp Pp 283+2 plates (Copenhagen Andr Fred Høst & Sons, 1959) 60 Kr [144

United States Department of the Interior Fish and Wild Life Service Fishery Bulletins No 109 Life History of Lake Herring of Green Bay, Lake Michigan By Stanford H Smith Pp iii+87–138 35 cents No 110 Observations on the Development of the Atlantic Sailfish *Istiophotus americanus* (Culvier), with Notes on an Unidentified Species of Istiophoris By Jack W Gehringer Pp iii+139–171 30 cents No 112 Yellowfin Tuna Spawning in the Central Equatorial Pacific By Henry S H Yuen and Fred C June Pp ii+251–264 15 cents No 113 A Method of Estimating Abundance of Groundfish on Georges Bank By George A Rounsefell Pp ii+265–278 15 cents No 115 Climatic Trends and the Distribution of Marine Animals in New England By Clyde C Taylor, Henry B Bigelow and Herbert W Graham Pp iii+293–345 40 cents Statistical Digest No 39 Fishery Statistics of the United States, 1954 By A W Anderson and E A Power Pp ii+374 2 dollars Statistical Digest No 41 Fishery Statistics of the United States, 1955 By A W Anderson and E A Power Pp ii+446 2 dollars Statistical Digest No 43 Fishery Statistics of the United States, 1956 By E A Power Pp ii+476 2 25 dollars (Washington, D C Government Printing Office, 1956, 1957 and 1958) [174

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Metropolitan Life Insurance Company Statistical Bulletin, Vol 40 (February 1959) Heart Disease in Middle Life Births Continue at High Level White House Conference on Children and Youth Tornadoes Take Fewer Lives Pp 12 (New York Metropolitan Life Insurance Company, 1959) [174

United States Department of the Interior Fish and Wildlife Service Statistical Digest No 42 Propagation and Distribution of Food Fishes for the Calendar Years 1955–1956 Prepared by the Branch of Fish Hatcheries, Bureau of Sports Fisheries and Wildlife Pp ii+44 20 cents Research Reports No 46 Past and Present Delaware River Shad Fishery and Considerations for Its Future By James E Sykes and Burton A Lehman Pp iii+25 20 cents No 47 Role of Coleman Hatchery in Maintaining a King Salmon Run By Oliver B Cope and Daniel W Slater Pp iii+22 25 cents No 48 Shad Fishery of Chesapeake Bay with special Emphasis on the Fishery of Virginia By Charles H Walburg and James E Sykes Pp iii+26 20 cents No 49 Ova Production of American Shad in Atlantic Coast Rivers By William S Davis Pp ii+5 5 cents No 50 Growth Rate of Browns Bank Haddock By John P Wise Pp ii+13 10 cents (Washington, D C Government Printing Office, 1957 and 1958) [174

United States Department of the Interior Fish and Wildlife Service Fishery Bulletins No 117 New Calanoid Copepods of the Families Aetideidae, Euchaetidae, and Stephodae from the Gulf of Mexico By Abraham Fleminger Pp ii+355–363 15 cents No 118 Zooplankton Abundance in the Central Pacific, Part 2 By Joseph E King and Thomas S Hida Pp iii+365–395 30 cents No 119 Early Development Spawning, Growth, and Occurrence of the Silver Mullet (*Mugil curema*) along the South Atlantic Coast of the United States By William W Anderson Pp iii+397–414 20 cents No 120 Larval Forms of the Fresh-Water Mullet (*Agonostomus monticola*) from the Open Ocean Off the Bahamas and South Atlantic Coast of the United States By William W Anderson Pp ii+415–425 15 cents (Washington, D C Government Printing Offce, 1957) [174

Laboratoire d'Astronomie de Lille Astronomical News Letter, No 92 Pp i+57 Astronomical News Letter, No 93 Pp i+52 (Lille Laboratoire d'Astronomie, 1959) [174

The Work of WHO 1958 Annual Report of the Director-General to the World Health Assembly and to the United Nations (Official Records of the World Health Organization, No 90) Pp x+252 (Geneva World Health Organization, London H M Stationery Office, 1959) 6 Swiss francs, 10*s* , 2 dollars [174

Compte-Rendu du Congrès International pour l'Etude Scientifique du Vin et du Raisin, 11, 12, 13 Octobre, 1957 Sous la Présidence Professeur Georges Portmann Pp 77 (Paris Comité National de Propagande en Faveur du Vin, 1959) [174

Jahresberichte des Deutschen Wetterdienstes, Nr 6 Jahresbericht 1958 Pp 72 mit 19 Abbildungen und 14 Tabellen im Text (Offenbach a M Deutschen Wetterdienstes 1959) [174

Food and Agriculture Organization of the United Nations FAO Nutrition Meetings Report Series No 21 Report of the FAO Nutrition Meeting in Europe, Rome, Italy, 23–28 June 1958 Pp ix+28 (Rome Food and Agriculture Organization of the United Nations, London H M Stationery Office, 1958) 2*s* 6*d* , 0 50 dollars [174

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO , LTD ,
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Telephone Number Whitehall 8831 Telegrams Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
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EDUCATION IN THE NEW WORLD

THE report prepared by the Science Advisory Committee to the President of the United States is a significant document for all free-speaking peoples (see p. 87 of this issue)*. It presents the views of America's leading men of science and technologists and examines the ways in which American education can be strengthened so that it will more fully meet requirements in this age of science. The principles upon which the report is based and the recommendations stemming from them have immediate relevance to the state of education in Britain to-day.

No one in the United States would deny that the country should have a first-rate system of education. Yet, says the report, many American citizens do not realize that the strength, and even survival, of democratic society are determined primarily by the excellence and appropriateness of its educational patterns. Nor is everyone aware that learning, though beginning during the school years, is a life-long venture; that education is a part of life and not merely a preparation for it. Unfortunately this lack of awareness is as common in Britain as it appears to be in the United States and, even more unfortunately, applies as much to specialists in education as to members of the general public.

A second declaration of the Committee would find ready acceptance in all countries with a democratic system of government. A modern educational system, the Committee believes, should not only sharpen the intellectual capacities and curiosities of each new generation, should not only extract the essential core from ever-accumulating stores of knowledge, should not only find ways to produce new leaders equipped to add to these stores and to create all the new tools that the civilization requires; it must also produce citizens and leaders who will know how to use the knowledge and tools to advance social and cultural life.

Nor should discussions on education, as so frequently happens at educational conferences and meetings, be confined to buildings or budgets or even curricula. These, indeed, are necessary means to the end. We must think of the end itself; to introduce the growing child, the youth, and the adult to the best and most essential elements of the intellectual and cultural experience of previous generations; to do this in such a way that we stimulate curiosity and encourage each individual to look forward, not backward, to develop his own talents to their maximum, and to continue this development throughout his life.

The Committee also proclaims its faith in education as the most important of all social activities. "It is right and it is important that we should expend great effort and resources in order that every American child shall have the opportunity for the ten, the fifteen, or even the twenty years of formal educational experience required to give him full command of his intellectual powers and enable him to live a rich and fruitful life, both as an individual and as a citizen".

These are the fundamentals of education in a democracy and need frequent examination to determine how far practice falls short of precept. In Britain they should form a useful corrective to the ever-present danger of complacency which bedevils educationists at local- and government-level, who, too often, use advances on limited fronts to obscure the lack of progress over the educational field as a whole.

The Committee's statement stands out chiefly for the importance it attaches to intellectual excellence, to the need for stretching students to the utmost of their capabilities, to enhancing the prestige of the teacher and to improving the standards of scientific education both for the specialist and the non-specialist; above all, and as the report makes very clear, for the recognition that the strengthening of science and engineering education requires the strengthening of all education.

The need for much greater emphasis on the gifted—though not at the expense of the less gifted—has considerable significance for Britain to-day. The President's Committee recommends that opportunities should be provided to draw out both gifted and less gifted to the limit of their intellectual and emotional capacities. Unfortunately, education cannot be considered outside the framework of the society for which it is intended and, in Britain, two opposing views have grown up. One, broadly represented as egalitarian, is pursuing policies which tend to reduce the facilities and challenge for more intellectual children by emphasizing that there must be equal opportunities available for all. In their quite natural desire to look after the weaker brethren it frequently means that the less gifted are given relatively greater attention and facilities than those with greater mental endowments. The other view, sometimes described as the superior, seeks, under the guise of character-training, to perpetuate a system in which mere attendance at a well-known school is thought to be more than adequate to make up for deficiencies in intellectual abilities.

The importance of character-training is continually being stressed in the British educational system, and much school work is attuned to this; the achievements are admired by the whole civilized world. Not enough recognition is given to the fact that it is the brain which wins the break-through to new knowledge; the child gifted with high intelligence should always be sought for and given opportunities to expand his intellectual capacities to the utmost. An 'egg-head' deserves wide admiration as a national asset, and should not be treated with mild amusement as a harmless eccentric.

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* "Education for the Age of Science" (The White House, Washington, D.C., May 1959).

If Britain is to survive in a world where educational systems will become increasingly scientific and technological, much more attention to the gifted child must be given both by those who proclaim equality and by the trainers of character Grammar schools, with their proved records of success, must not be lightly abandoned in favour of experimental comprehensive schools simply to satisfy political aspirations and clamour The major public schools, with their proved records of success, could provide a very much greater service to the nation if entry to them were governed by intellectual and emotional capacity rather than by the parents' ability to pay Unless they are prepared to change in the interests of the whole nation, existing methods of entry to these schools may well lead to their own undoing

Nor can the gifted child be developed where its early days are spent as a member of a class of forty or so children in a primary school Here the aspirations of the Ministry of Education and of the teaching profession are remarkably low in that the provision of classes of thirty at all levels would seem to usher in the millenium The difference between the quality of boarding school education and day school education may not be so much due to the residential factor as is commonly supposed Much more important may be the fact that education in the public schools is organized on a much more individual basis, whereas the State system of education still savours of mass production One of the strengths of the grammar schools has been the individual attention paid to scholars in sixth forms With the development of much bigger sixth forms in comprehensive schools, junior colleges and bigger grammar schools, there is the danger that State schools may decline in quality compared with the public schools, where classes of thirty would often be regarded as three times too many

In his introductory comments to the Committee's report, President Eisenhower writes that one subject warrants special emphasis—"the importance of raising the standing of our teachers in their communities Higher salaries are a first requirement, but we need also to recognize the great importance of what teachers do and to accord them the encouragement, understanding and recognition which will help to make the teaching profession attractive to increasing numbers of first-rate people" The President's belief and wish would find many echoes in Britain as well as a re-echo about whether or not the teaching profession goes the right way to deserve greater prestige The growth of pressure groups inside the profession, the emergence of trade union organization and of threats to strike, and the annual conferences at which the only topics discussed are pay and conditions have all helped to build up a public opinion which does not always see the teacher as a man dedicated to his calling If the teacher is to enjoy greater status he must first of all prove worthy of it This is unlikely to occur so long as the dominant voice comes from teachers who have been trained for only two years and who make up the large majority of the profession

Practical means by which the status and quality of the teaching profession could be improved are described in the report and could well be copied in Britain A closer and continuing link with universities and research institutions, the provision of more refresher courses at which leading men of science and technology keep teachers up to date with new knowledge and discoveries, collaboration between outstanding scientists and teachers in the design of new curricula to give pupils an "introduction to those areas of science and technology essential to an understanding of the problems of a modern society", the scholar's guidance and help in the provision of new text-books of science and technology at all levels, an adequate supply of films, television programmes, slides and tape-recordings to help the teacher in his work—these and other ways should and will increasingly have to be used if the teacher is to remain reasonably up to date in a rapidly changing age of science There is little use in changing curricula unless the teachers have the new knowledge and are competent to teach it

To help the teacher to remain aware of developments in technology, contacts with industry should be much closer than they are to-day This will not only help him to keep abreast of advances in technology, but will also enable him better to understand the industrial life which the majority of his pupils adopt on leaving school

The need to broaden the outlook of the specialist in science by giving him an introduction to other departments of science and technology has been well recognized in Britain by university extra-mural departments The latter have also done valuable pioneering work in enabling the non-specialist to grasp the wider implications of science in society Their efforts have been much curtailed by restrictive financial policies , the reports of extra-mural departments at Oxford, Nottingham and other universities for 1958 should be read in conjunction with the call to action set out in the report of the President's Committee

How much more could have been done has already been shown by those area committees of the British Association for the Advancement of Science which are not only taking outstanding lecturers to large and enthusiastic audiences from women's institutes, etc , but are also answering the long-expressed wish of provincial cities like Liverpool, Nottingham and Sheffield for their own "Royal Institution Christmas lectures" The British Association area committees should now see that any special lectures arranged should not only be available for school-children but also for apprentices, whose formal education is far from complete , receptive and ready-made audiences will also be found in various foremen's and managers' groups inside factories themselves

The Committee's report directs attention to the lack of science teaching in the liberal arts colleges of the United States While in Britain there is no close parallel to these colleges, it is surprising that, even in 1959, the many theological colleges pay little or no attention to the teaching of science It is difficult to believe that some of the time spent on dogma might not more profitably be spent in making prospective parsons familiar with the broad paths of science , courses in social anthropology might be of practical concern to future missionaries

That the strengthening of science and engineering education cannot be undertaken except by strengthening the country's general educational system is a point well made by the Committee and underlined by the President himself In Britain the direction is right, but it may well be considered whether the pace is rapid enough There are still too many black-listed schools Hopelessly overcrowded classes in primary schools present teachers with problems in which education is replaced by mass instruction The high hopes held out for secondary modern schools have not been fulfilled County colleges remain a dream, and, because of the shortage and quality of staff at many technical institutions, the facilities available for many day-release students often account for appalling wastages between the first and last years of City and Guilds and National Certificate courses Shortages of competent lecturers in mathematics and science at teachers' training colleges have led to a vicious circle which results in the bad teaching of mathematics and science in many junior schools The lack of hostels for students in senior technical colleges and universities and consequent living in overcrowded lodgings makes many university lives narrow and drab

These are some of the features of the British educational system which should be examined when too much is made of our advances The report of the President's Advisory Committee should have both a stimulating and salutary effect in Great Britain, in the United States and in the whole Western world

EXTREMELY HIGH TEMPERATURES

Conference on Extremely High Temperatures

Boston, Massachusetts, March 18–19, 1958 Edited by Dr Heinz Fischer and Lawrence C Mansur (Sponsored by Electronics Research Directorate, Air Force Cambridge Research Center) Pp xi + 258 (New York John Wiley and Sons, Inc , London Chapman and Hall, Ltd , 1958) 78*s* net

THIS volume is an account of the first conference on extremely high temperatures sponsored by the U S Air Force Cambridge Research Center, under the chairmanship of Dr Heinz Fischer At first sight it looks as though the U S Air Force were in competition with the Atomic Energy Commission in supporting thermonuclear research at a time when those activities of the Commission called "Project Sherwood" were all classified, and there are clear indications that investigators under the Air Force contract are covering some of the ground the Atomic Energy Commission's scientists had covered long before But the conference was based on a broader realm of science than thermonuclear research , it embraced the study of high-current arcs and materials capable of withstanding extremely high temperatures, with the result that all subjects were treated rather sketchily and a specialist reader is likely to be interested in only one or two papers in the volume

Several papers deal with the development of very high speeds of small pockets of gas driven by shock waves, work not unlike the large quantity of work reported by Post and others from Livermore Janes and Patrick accelerated an annulus of gas between cylinders to 3×10^7 cm /sec with currents rising at 10^6 amp /μsec , and Bostick describes the propulsion of a small volume of plasma at 2×10^7 cm /sec ejected from a deuterium-loaded titanium gun, while Nadig and Bohn give a preliminary account of the shooting of a plasma of exploded wire between long copper plates

Several papers deal with the study of high-powered arcs at atmospheric and higher pressures, arcs dissipating 1,000 kW of d c power, stabilized by a water sheath such as was originally developed at Kiel The plasma of gas emerges from the arc chamber at temperatures up to 15,000 degrees and is constricted to some extent by the electrical pinch-effect Ghai mentions that the most serious limitation to the application of these very high-intensity plasmas has been the erosion of electrodes, and states that in the past year such erosion has been reduced a hundredfold, but unfortunately he does not state how this has been achieved. Bonin and Price, on the other hand, present informative figures on the ablation and erosion of different materials—which might be used in rocket cones—when subjected to the plasmas from these arcs

A session on temperature measurement produced some valuable papers Drummond outlined the microwave properties of high-temperature plasmas and showed that it should be possible to record with microwaves temperatures leading up to fusion Pearce presented valuable calculations about the density of light-emitters deduced from the observed brightness across the diameter of a cylindrical light source, and two papers deal with the deduction of arc temperatures from the hydrogen-line broadening

There are several brief papers on energy storage, capacitative and inductive, and one by Finkelstein outlines the application of a 100,000-joule bank of condensers having specially low inductance (one millimicrohenry total) to develop a betatron field of up to 200,000 gauss over an orbit of 5 cm radius, to achieve the particle acceleration needed to disintegrate matter not into the 'fourth state', namely, electrons and protons, but into the 'fifth state', namely, nucleons and mesons In this connexion Levine *et al* review the problems encountered in generating magnetic fields up to 750,000 gauss for milliseconds The article on the feasibility of thermonuclear propulsion sounds like science fiction and my reaction was "first catch your hare"

T E ALLIBONE

ELECTRON TECHNOLOGY

Electron Physics and Technology

By Dr J Thomson and E B Callick (Physical Science Texts) Pp xiv + 527 (London English Universities Press, Ltd , 1959) 50*s* net

THE publishers say that this work is intended to provide a sound theoretical basis for the student who is pursuing an honours degree in either physics or electrical engineering In fact, the authors seem to have cantered lightly over the fields of electron physics and elementary valve circuits, skirting around difficulties, and reserved their energies for the technology The physicist may be assumed to learn his electron-physics elsewhere, but is it fair to the engineer to show him on p 20 a graph from which the most probable energy of a (conduction) electron in a metal is seen to be about 2eV at room temperature, but then to tell him on p 84 that the most probable electronic energy in a metallic conductor is *kT* ? Again, on p 111 it is stated that a class *B* push-pull amplifier is biased to zero standing current Does not the student deserve a more realistic treatment, even if that requires some further explanation of the actual shape of a valve characteristic ?

Sections 4, 5 and 6, on microwave devices, special-purpose tubes, and materials and construction, are at a much higher standard, and it is perhaps significant that most of the chapters in these parts give some reference to other published work, while the earlier chapters do not The chapter on switching and scaling tubes is particularly valuable

As must always happen in a rapidly developing subject, history has overtaken the authors They have covered travelling-wave tubes up to the stage of using a velocity-jump to reduce beam noise, and they have a chapter on transistors , but they do not deal with the maser, which involves concepts of sufficient importance to be studied by anyone interested in the fundamentals from which the future of electron technology will spring The general impression is that this book is good on electron technology but does not deal with principles as well as one is led to expect from a book which claims to cover physics as well as technology D A Bell

PLANT MORPHOLOGY

Comparative Morphology of Vascular Plants

By Adriance S Foster and Ernest M Gifford, Jr (Series of Books on Biology) Pp xi + 555 (San Francisco W H Freeman and Company , London , Bailey Bros and Swinfen, Ltd , 1959) 9 dollars , 76*s* 6*d*

THE aim of the authors of this very attractively produced text-book is, as stated in the preface, to give not only a purely factual description of the main groups of vascular plants but also to indicate the general principles and objectives of comparative morphology They express the hope that the text will "in some measure orient and vitalize the teaching of plant morphology"

The general plan of the book is a little unusual The first six chapters are described as "orientation chapters" and deal with the principles and problems of comparative morphology Some of the topics briefly discussed are the criteria used in phylogenetic interpretations, the stelar theory, alternation of generations, the telome theory, the phylogeny of sporangia and gametangia, embryogeny A brief account of the aims and methods of experimental morphology is also given Although this arrangement has some advantages, it seems probable that these general discussions would be more useful if they followed, rather than preceded, the descriptive chapters

The main part of the book covers the whole of the so-called Tracheophyta It deals in turn with the Psilopsida, Lycopsida, Sphenopsida and Pteropsida, the last-named being a group which will appear heterogeneous to many botanists The descriptions of the various phyla are excellent, and include some account of fossil representatives and of the cytology As the field covered is so wide, it is, however, inevitable that some aspects should be treated very briefly As might be expected from the research work of the authors, the chapters on the Gymnosperms and Angiosperms are particularly interesting and lucid Many references are made throughout to standard works and other literature, and the references are listed alphabetically at the end of each chapter

The book is fully illustrated by line drawings and photographs For the most part these are excellent and closely related to the text No magnifications are, however, given for any of the figures, and in some instances the specific name of the plant illustrated is omitted from the legend These omissions tend to lessen the value of otherwise excellent illustrations Many of the line drawings are described as being "redrawn" from various sources when it would have been better to use the phrase "based on". This is so in examples where the copying has not been precise (though not misleading), or where shading has been introduced or a pictorial background added In one instance, photographs are said to be "redrawn"

The book may be recommended to students as giving a good general picture of evolutionary trends within the Tracheophyta At the same time it indicates, though perhaps without sufficient emphasis, the difficulty, and often the impossibility, of reaching final conclusions in phyletic morphology The references to recent work on morphogenesis, experimental morphology and cytology should be of value to students as indicating lines of research of great intrinsic interest apart from their possible bearing on the many persisting problems—or "abiding mysteries" as the authors call them—of comparative morphology S Williams

ELECTROPHORESIS IN THEORY AND PRACTICE

The Principles of Electrophoresis

By René Audubert and Serge de Mende Translated by A J Pomerans Pp viii+142+16 plates (London Hutchinson and Co (Publishers), Ltd , 1959) 25*s* net

Electrophoresis

Theory, Methods and Applications Edited by Milan Bier Pp xx+563 (New York Academic Press, Inc , London Academic Books, Ltd , 1959) 15 dollars

IT must be admitted that many people who employ electrophoretic methods have little more than a passing acquaintance with the principles involved in the techniques they are using These two books should enable everyone to know what they are doing, whether they undertake moving-boundary, paper or most other variations of electrophoresis Both these books cover the whole field and so conveniently bring together information which hitherto has been scattered

Audubert and de Mende's volume forms a useful theoretical introduction , the principles of electrophoresis are set out clearly and systematically and the translation has been well done Beginning with the general properties of electrolytes, the book passes on to colloidal systems, electrokinetic potential and electrophoresis Then follow sections on the principles

JOURNAL OF CHILD PSYCHOLOGY AND PSYCHIATRY
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Official organ of the Association of Child Psychology and Psychiatry

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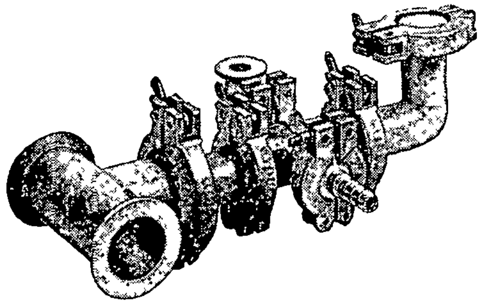

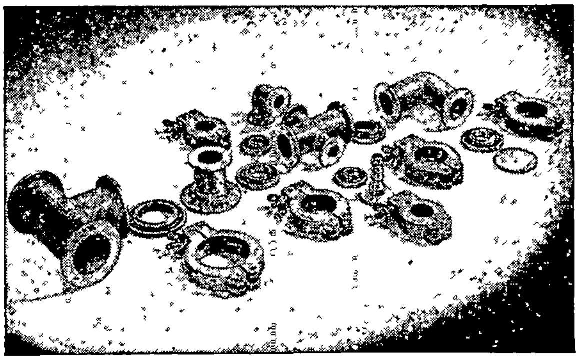

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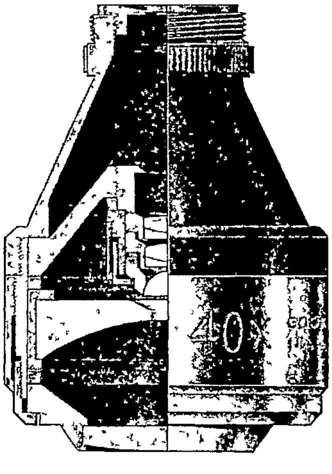

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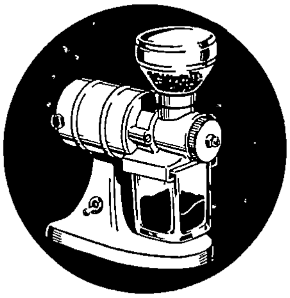

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underlying moving boundary and paper electrophoresis Finally, other zone methods and applications are described Unfortunately, with one exception (and that is a review article), all references are no later than 1954 , consequently some of the matter in the last part of the book is somewhat out of date and some recent important developments are not covered Part of the section on applications is rather sketchily done, and brief descriptions are not supported by references (pp 137–138) The book's chief value lies in its theoretical exposition, but there are one or two flaws The dissociation of proteins (p 13) and of amino-acids (p 70) is represented by concepts which have long ago become obsolete , even more serious is the last paragraph on p 70, which fails to recognize that an ampholyte can have a net charge (and therefore move as a single zone towards an electrode) when it contains both positively and negatively charged groups This is surprising, especially as, two pages further on, the concept of net charge is recognized There are a few less serious errors such as "sulphate" for "sulphide" in Fig 77 and p 106, and in Fig 78 the photometer tracing is reversed relative to the strip Nevertheless, I believe that this book will prove to be of great value to most people who are using electrophoretic methods, and if, as I hope, it reaches a second edition, opportunity should be taken to rectify the few errors and include more up-to-date matter

The book edited by Bier treats in greater detail the theory and practice of electrophoresis It consists of a series of articles on selected topics, each written by experts The first two, by Overbeek and Lijklema and by Linderstrøm-Lang and Nielson, deal very fully with the fundamentals of electric potentials in colloidal systems and acid-base equilibria of proteins There are three excellent chapters on moving boundary electrophoresis (Longsworth on theory and practice , Brown and Timasheff on applications to protein systems) Paper electrophoresis is covered well by Wunderly, and Kunkel and Trautman deal with other zone electrophoretic methods, including important recent developments such as starch gel, cellulose column and immuno-electrophoresis Applications of zone methods are covered by Wieland Bier's article deals with preparative electrophoresis without supporting media and is an excellent survey of methods depending on density gradient, electrodecantation, electrophoresis convection and forced flow electrophoresis An addendum to this section describes electrophoresis in non-aqueous solvents and gives the impression that this is a very recent development, but I think that Karagounis (*Nature*, **161**, 855 , 1948) should receive credit for originating the method described Of particular interest to those working in the medical field is Moore's article on clinical and physiological applications Britten and Lauffer give a fascinating account of electrophoresis of viruses, bacteria and cells, and of the microscopic method of observation

There is a certain amount of overlapping, probably difficult to avoid in a book of this nature, and it might have been a more logical arrangement for Wieland's contribution to have followed that of Kunkel and Tiselius, and for Brown and Timasheff's chapter to have followed Longsworth's But Dr Bier and his collaborators are to be congratulated on an outstanding contribution to the literature of electrophoresis There is little doubt that the hope expressed by him in his preface that this would be an authoritative work has been realized R CONSDEN

A SOURCE BOOK OF FUNGAL PHYSIOLOGY

Physiology of Fungi

By Prof Vincent W Cochrane Pp xiii + 524 (New York John Wiley and Sons, Inc , London Chapman and Hall, Ltd , 1958) 78*s* net

DURING the past thirty years interest in physiology and biochemistry of the fungi has been increasing, but it has received additional encouragement by the publication in the last ten years of several books These have brought a mass of short papers and accounts of experimental work within the easy reach of all biologists Each of these books has treated its subject in a different way, some giving emphasis to chemistry or to functional physiology, others perhaps attempting to review the whole subject at an undergraduate-level The result has been wholly beneficial to mycology itself, for it is now possible for those interested in particular in taxonomy, ecology, pathology or genetics of the fungi to apply to their own work the information gained by laboratory study of physiology Further, the yeasts and a few moulds are no longer the only polite subjects of physiological and biochemical inquiry among the fungi, but have come to be seen for what they often are, rather specialized organisms

Prof Cochrane has had several aims in preparing his book, and these he has achieved with skill He has attempted to review the literature on fungal physiology particularly mentioning work done in the past thirty years, to emphasize those results of a truly experimental and quantitative nature, and to show clearly what parts of the subject present outstanding problems which still require quantitative investigation Certain aspects of physiology have been intentionally omitted, such as the interaction of organisms with one another This subject is so vast that the need for its omission is easily understood

The book as a review of the available information is remarkable for the number of works to which it refers In 379 pages of text some 4 5 × 10^3 references are quoted which are grouped at the end of each chapter so that their use is greatly facilitated Although they are so numerous, they still only comprise a selection made by the author from a much greater number, and this itself indicates the magnitude of the subject of fungal physiology The selection has been good, and as long as one remembers that emphasis has been given to biochemical rather than physiological and to quantitative rather than qualitative information, the book is greatly improved by it Each reference does not, of course, receive detailed appraisal, but the important and difficult aspects of each problem receive comment and criticism designed to place them in proper perspective At times the space allotted to important subjects is a little too restricted For example, the general remarks on metabolism of oligosaccharides in Chapter 5 are unlikely to be easily understood by anyone meeting the subject for the first time

The book as a whole is good and will be found especially valuable as a reference book for all those interested in fungal physiology It may be used to obtain a short critical survey of a problem and also as a guide to references from which fuller details may be obtained

J L HARLEY

A UNIVERSITY OF GRADUATE STUDIES*

By Dr. DETLEV W. BRONK, O.B.E.(Hon.), For.Mem.R.S.

President of the Rockefeller Institute, New York, and of the U.S. National Academy of Sciences

SINCE the beginning of the University of Bologna nine centuries ago, many universities of many kinds have been created in many places; all have been created to satisfy the same deep desire of men to learn and teach. Because universities satisfy that desire, which is unique to human kind, universities have been among the most enduring of human institutions. Their vitality has been attested by their ability to sustain their basic purpose within changing patterns of structure and of action. Various and changing circumstances have evoked universities of various characteristics.

Since the beginning of the Rockefeller Institute, only half a century ago, it has provided rich opportunities for men to learn. It has been a community of scholars who were privileged to explore the frontiers of natural knowledge. Our predecessors have left us a heritage of traditions of intellectual excellence and adventure. They laid strong foundations for a house of learning.

Five years ago we determined to build further on those foundations, so that we might welcome our young successors to this community of scholars and gladly teach and guide them as they prepare for scholarly careers. To-morrow we will speak of new buildings of glass and stone, of modern art and natural beauty. To-day I speak of building an academic structure in which youth may learn from the elder, and the elder have the intellectual stimulus of the younger.

As we have extended the scope of the Rockefeller Institute and assumed the new responsibilities of a School of Graduate Studies, we have thought deeply of our obligations to satisfy the traditional standards of institutions of higher learning. I have personally felt that sense of responsibility keenly, for my life and those of my forebears have been lived in academic places which we prized highly.

I would here quote, as I will do again, from Rashdall of Oxford, the great biographer of European universities in the Middle Ages. "It behooves us not", said he, "to lose or lower the ideal of the university as the place *par excellence* for professed and properly trained students, for the highest intellectual cultivation, for the advancement of science, and not merely for its conservation or diffusion. . . . Whether a particular institution should or should not be called a university may seem by itself to be a little thing, but the name has got to be associated with education of the highest type. It is by no means essential that all should conform exactly to the same pattern. The two most essential functions which a true university has to perform, and which all universities have more or less discharged, amid the widest possible variety of system and method and organization, are to make possible the life of study, whether for a few years or during a whole career, and to bring together during that period face to face, in living intercourse, teacher and teacher, teacher and student, student and student".

Familiar though these functions be, it is appropriate, I think, to state them and restate them in these times of turmoil. The tranquil, contemplative life is harassed and eroded by the busy demands of the moment. The explosive growth of populations requires much wisdom for the preservation of the precious intimacy of relation between a scholar and a scholar and between scholars and those in other walks of life.

Those functions are two of the objectives of the Rockefeller Institute. The first need not be justified to an academic audience such as this, but the significance of that function is less apparent to many all about us who value academic institutions most or only for the training that they gave as preparation for the performance of specific tasks. They value research as discovery of useful knowledge; too few, unfortunately, perceive research as a happy, exciting adventure that gives vitality to our culture.

The Rockefeller Institute is fortunate in its heritage of advice from its founder, who took a longer view and often said to those who studied here, "Don't be in a hurry to produce anything practical. If you don't, the next fellow will. You, here, explore and dream".

It is our purpose to follow that advice and make the Rockefeller Institute a place in which to live a life of study. Though that be a privilege which is sought by many, the Institute will severely limit the number of those who study here, so that those who do so may come together, face to face, in 'living intercourse'. Such limitation is not easy, for refusal never is, and in the United States, all too often, size appeal is an overpowering temptation to sacrifice excellence for numbers. There is appropriate wisdom in the words of Ellery Sedgwick, who said: "One can influence many by inoculating the influential few", as did *The Atlantic Monthly*, of which he was then editor.

Specialization seems necessarily to follow increase of knowledge. New specialties and specialists seem to breed new university departments, and so the scope of universities seems necessarily to grow, and thus to satisfy the needs of a more complex civilization. But some graduate schools could become superlatively good by restricting the scope of their endeavour to immediately related fields.

That was said to me by Abraham Flexner as I began my professorial career in 1926. That year he, also, wrote in *The Atlantic Monthly* some words which I would read as these: "The range of certain universities could be greatly reduced. Moreover, modern science and scholarship being what they are, universities could be very irregular affairs. No single science can be completely represented anywhere; still less, all sciences . . . and institutions most concerned with science would almost inevitably be less adequately developed on the humanistic side Nor does it greatly matter the very incompleteness of single institutions will force all real universities in the higher sense to view themselves as parts of one great organic whole"

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* Substance of an address delivered on May 21 at the first Rockefeller Institute Convocation for Conferring of Degrees and Dedication of New Buildings (see also *Nature* of June 13, 20, 27 and July 4, 1959).

Perhaps Flexner read Rashdall also, for there I find "The word *universitas* is one to which a false explanation is often assigned for polemical purposes by controversial writers, while the true explanation of it at once supplies us with a clue to the nature and historical origin of the institution itself The notion that a university means a school in which all the faculties or branches of knowledge are represented has indeed long since disappeared from the pages of professed historians, but it is still persistently foisted upon the public by writers with whom history is subordinate to what may be called intellectual edification"

"However imposing and stimulating may be the conception of an institution for the teaching or for the cultivation of universal knowledge, however imperative the necessity of such an institution may seem at times to be, it is one which can gain little support from the facts of history To glance into any collection of medieval documents reveals the fact that the word 'university' means merely a number, a plurality, an aggregate of persons"

One of the most needed functions of a school of graduate study in these days of specialization is to foster broad foundations upon which a man may build competence to deal with problems yet undreamed of Broad foundations of interest in many related fields of science and wide knowledge are essential to a scientist who would be a scholar

Sir George Trevelyan, a Master of Trinity College, Cambridge, in speaking of the friend of whom he then was writing, said "He was an outstanding example of a type that has always specially attracted me the specialist who has a wide outlook, broad knowledge, and warm enthusiasms outside his own subject as well as in it, and more particularly, a man, he was, whose mind has been trained in the splendid discipline of a science, but whose heart and eyes take also delight in the triumphs of art, in the history of man, in the beauties of Nature Such a man is about the best thing that our modern civilization can produce"

We hope that in the Rockefeller Institute we may fit students to become men such as the one of whom Trevelyan spoke We would relate science to all other forms of creative endeavour We will strive to interpret science as a great Odyssey of the human spirit In order to do so we will draw upon all the resources of the learned world that may be available to us in order to emphasize the proper place of science in the total structure of man's creative effort We seek to make an environment in which men and women can pursue knowledge not as a grim undertaking, not as an undertaking for the achievement of immediate, practical, ends, but as a happy, joyous pursuit of knowledge which will enrich all their lives, and the lives of all those about them

EDUCATION FOR THE AGE OF SCIENCE

AN outstanding statement on the place of education in the life of a nation has recently been published by the Science Advisory Committee to the President of the United States of America Issued with the warm encouragement of the President, the report sets out the national goals for strengthening science and engineering education and urges support by all American people to meet these goals (see also p 81 of this issue)

The American outlook is conditioned by the traditional dedication to the proposition that most of her children shall have a long educational experience, that no child shall be deprived of the fullest opportunity to develop his own talents, and that the people of each local community shall, to a large degree, be autonomous in the decisions they make about the education of their own children In theory it is intended that the brilliant child shall be able to develop brilliantly , that the slow or backward child shall be nurtured patiently , that the artisan shall not be considered inferior to the intellectual because he is an artisan, if only he is a good one , that no one shall be condemned to a lowly position or elevated to a high one by the mere circumstance of the wealth, power or prestige of his ancestors

These are the premises, and most American educational policies are based upon them Yet there are inconsistencies Very few Americans, for example, would insist that the words of the Declaration of Independence require that all Americans be equally competent in intellectual matters and that they should, therefore, automatically pass together from grade to grade in school Occasionally this seems to be the policy

Americans do not really think that educated people are dangerous or silly—yet the terms 'egg-head' and 'intellectual' are not always terms of approbation Americans occasionally act as though they feared the word 'excellent', especially as applied to mental achievement In other words, the practices do not always live up to the ideals

After a close and penetrating analysis of the American educational system, the Committee defines certain goals the attainment of which would strengthen science and engineering education in the United States The goals are based upon the belief that a changing civilization will demand an even greater devotion to learning and a greater pride in intellectual achievement "The profound effects of recent advances in science and technology demand that scientific literacy be far more widespread among the American people if we are to solve the problems of this age"

The Committee recommends that

(*a*) Americans should attach greater value to intellectual excellence

(*b*) Every school and college should re-examine its curriculum to make sure that in every aspect it is giving adequate challenge to the intellectual capacities of its students

(*c*) Much more should be done to enhance the prestige of the teacher and to provide him with more effective support in his efforts to improve the effectiveness of his teaching (*d*) Educational programmes should be adapted to the widely varying competence of students, and especially to the needs of the most gifted students

(*e*) Scientific education at all levels should be improved to give better understanding of science to the non-scientist as well as to discover and stimulate more individuals who have the talents to become scientists and engineers

To attain these ends four major areas need specific and urgent attention throughout the educational system These are the curriculum and content of courses, the quality and effectiveness of teachers, the recognition and encouragement of students, and the development of intellectual leadership

The quality and content of the curriculum are central in education At every level in the school, college, and graduate school the curriculum must provide the basic educational materials required of all students, plus the broad selection of opportunities appropriate to the student body involved For those at higher levels in the educational system, it becomes increasingly important that the course content give recognition to the range of abilities of individual students, and, of equal importance, that each student be guided to the subjects best suited to his own innate talents

Especially in rapidly changing fields like science and technology, curricular changes must occur decade by decade, and even year by year At the secondary school level there are problems of balance between vocational and academic courses, and, at the college and university level, the problem of balance between the sciences, the humanities, and the social sciences

The Committee urges scientists and scholars to establish more intimate contact with experienced teachers at all levels, so that the curricula and teaching and learning aids in schools, colleges and universities may take account of the new facts and the new points of view that scientific progress has revealed

The Committee also recommends that a research programme be established by an appropriate foundation or agency in which scientists, scholars and teachers co-operate to design more adequate curricula planned to give all educated citizens an adequate introduction to those areas of science and technology essential to an understanding of the problems of a modern society

Since the content of courses in mathematical and scientific fields at both the secondary and undergraduate college level does not adequately recognize scholarly advances in these fields, the Committee recommends that present efforts be aggressively pursued and substantially expanded in bringing together leading scientists, scholars and teachers in these various subject-matter fields to seek

(1) To bring the course content in each subject at each level into line with the most modern scholarly research in its field, consonant with the level of instruction

(2) To outline, write, publish, and revise the necessary text-books and auxiliary reading materials to achieve these objectives

(3) To develop and supply adequate teaching and learning aids of all appropriate kinds, including motion pictures, television, tape recordings, slides, and other audi-visual materials designed to aid the student in understanding the subject more thoroughly, and especially to relieve the teacher of unnecessary burdens of preparation and instruction, and to enable the outstanding teacher to reach a much larger number of students

(4) To develop and supply laboratory equipment and materials for science courses together with the necessary manuals and reading materials to make the laboratory and field work a far more meaningful, useful and exciting aid to student and teacher

On the quality and effectiveness of teachers, the Committee would like scientists and engineers in universities and industries to establish organized programmes of collaboration with high-school and college teachers in order to reduce the gap in communication and understanding between these groups, rendering assistance and providing teaching material to teachers and their students, and bringing high-school and college students and teachers into more direct contact with scientific and scholarly work in universities and industry The economic and social status of teachers at all levels should be improved, enabling them to devote more of their working time to teaching tasks rather than administrative chores, and allowing them more time for preparation and study in their chosen fields Private and government agencies should evolve State and national programmes for providing substantial rewards, prizes, and other recognition to outstanding teachers in both elementary and secondary schools

A research programme should be sponsored on a national scale to bring together a key group of scientists and scholars to collaborate with teachers and educators on the problem of designing more adequate curricula for the education of high-school and college teachers, especially in the sciences and mathematics, with the aims of reducing the alleged conflict between subject-matter and methodology, making teacher training programmes more attractive to the best students, and bringing about a better understanding between scholars, scientists, teachers, educators and the public in regard to the philosophy, goals, and methods of the educational system

With the assistance and encouragement of the universities, the nation's best scholars should join the nation's great teachers in the task of determining how the great teacher may be brought before an even larger number of students

To recognize and encourage students, the Committee asks the American people to accept as a national goal lifting the student performance to higher levels of excellence by greater motivation and by the provision of rewards for intellectual achievement and more adequate and extensive opportunities and challenges to the highly gifted student A nationwide effort should be made to pay more attention to the academically talented students (that is, those in the upper 15–20 per cent of the age-group in intellectual ability) and to the unusually gifted students (that is, those in the upper 3 per cent of the age-group) Such an effort should involve citizens, school-boards, parents, teachers, together with State and national agencies, public and private Talented students should be recognized at an early age and given guidance and counsel in planning their educational programmes and in preparing for and choosing college and university work These gifted students should be given the necessary help in financing their educational programmes in high school as well as in college and in graduate school Such students should be rewarded and encouraged for their achievement in order that they may take pride in intellectual excellence, even at an early age

In considering the development of intellectual leadership, the Committee concludes that the intellectual, cultural and material advances of any society depend upon the quality of its leadership—upon its scholars, teachers, lawyers, industrial leaders, scientists, engineers, doctors, and other professional people. "These individuals are stimulated and educated in the colleges, universities and graduate schools of the country. To stimulate and educate the intellectual leaders of the future, we maintain a wide variety of colleges and universities located in every region of the United States. These institutions are continually seeking to improve the quality of the intellectual experience which they offer to qualified students in all fields. All, however, need much more help and support in these efforts".

The Committee is concerned about the slow progress which many of these institutions seem to make in their dual task of providing all their students with an adequate introduction to science and technology and the part they play in modern society, and providing adequate educational programmes to those with the talent for and interest in achieving professional careers in science, engineering and technology.

The separate liberal arts college and the college of arts and sciences of the great universities constitute basic training grounds for most of the leaders of to-morrow. There are overwhelming reasons why such citizens should acquire a reasonable introduction to the principles of science and technology on which the modern industrial society is based. Scientists and scholars should give greater attention to assisting the undergraduate colleges in providing adequate programmes in these fields.

From these conclusions it is specifically recommended that the curricular revision programme now being developed for high-school science courses be extended to undergraduate college courses in science and mathematics; aid be rendered to liberal arts colleges in examining their curricula to assure that they are adequately providing for scientific education of the non-scientist as well as of the future scientist or engineer; improving the number and quality of schools of science and engineering should be accepted as a national goal; university graduate schools in science and engineering should be enlarged in number and improved in quality, far greater emphasis being placed upon graduate work in engineering; the engineering colleges of the country should collaborate to improve and modernize their courses in engineering to ensure that able students are attracted to these courses and that they are given adequate training to meet the engineering and technological problems of to-morrow; government agencies concerned with research in science and engineering should re-examine the terms of their research support to educational institutions, with the view of avoiding placing a financial burden or penalty on such institutions by inadequate coverage in research contracts or grants of costs properly chargeable as overhead and for management allowances. Without serving as a subsidy in any way, proper handling of these fiscal matters can make certain that the research support will not affect adversely the opportunity to use the research effectively for the education of students, for the attraction and retention of able faculty members, and for the release of teachers and students from burdensome administrative and fiscal restrictions.

CURRENT TRENDS OF STRONTIUM-90, STRONTIUM-89 AND CÆSIUM-137 LEVELS IN MILK

By W. ANDERSON, L. K. BURTON and J. O. CROOKALL

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IT is widely recognized that milk is an important proximate source of the long-lived fission products present in the human body. In a recent communication[1] we summarized the main information available on the levels of radiostrontium and radiocæsium occurring in milk produced in Great Britain. In the case of strontium-90, the evidence pointed to some regional and seasonal variation, but viewed over the period 1955 until May 1958 it appeared that the levels had remained fairly steady. The picture for cæsium-137 was similar but was complicated by the additional deposition resulting from the Windscale accident. A recent report by Booker[2] extended the available information on cæsium-137 levels, and, in addition, showed that substantial increases of these levels occurred during June 1958 in milk drawn from nine different areas. This article reports detailed experimental observations made by us on the levels of strontium-90, strontium-89, and cæsium-137 occurring in milk produced in west Cardiganshire (Felinfach Creamery) throughout 1958.

The samples referred to in this article form part of the series described previously[1]. It was not possible to obtain dried-milk samples from the Creamery after September 1958 but the series was continued by employing liquid milk samples. To ensure that the sampling procedure remained as fully representative as hitherto, arrangements were made at the Creamery so that the final liquid sample was prepared from numerous periodic samplings of a total day's production. The methods of measurement used were also essentially those described previously. In the case of cæsium-137 in liquid samples, the measurements were conducted on the ash, after a number of tests had shown that no significant loss of this nuclide occurs during either the evaporation or ashing procedures employed.

As before, the samples were received at weekly intervals and measurements made on bulked samples, compounded from four consecutive weekly samples. The values obtained for 1958 are shown in Fig. 1. The main features of the results for each nuclide studied are as follows.

Strontium-90. As shown in Fig. 1*a*, the strontium-90 levels started to rise in April from a steady winter value of about 7·5 s.u., reaching values of 16·5–16·9 s.u. during May–July (1 s.u. = 1 μμc strontium-90/gm calcium). The levels are in the region of 14 s.u. during the autumn but rise again to 16·6 s.u. during November. The levels found for January and February 1959 were 13·4 and 15·3 s.u., respectively. It should be noted that the values found during January–April reflect levels present in winter fodder while later values until December reflect levels occurring in the pastures.

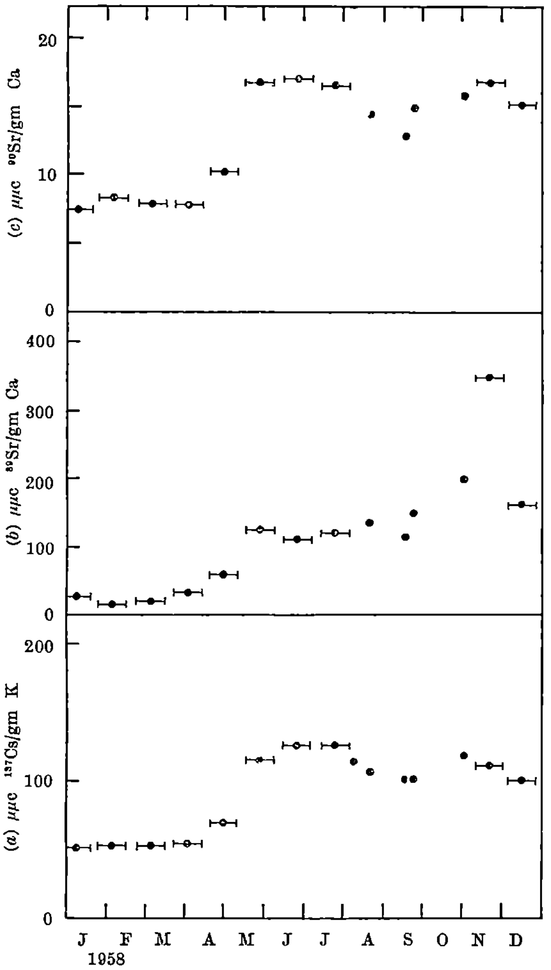

Fig 1 Levels of fission products in milk from Felinfach, west Cardiganshire, Wales (1958)

The values recorded after April 1958 are substantially higher than those found previously by us[1] for milk produced at Felinfach and by Bryant *et al* [3] for milk derived from neighbouring pastures (Carmarthen) Taken together the Felinfach and Carmarthen results gave a picture of fairly steady levels in the range 5 4–8 4 s u over the period October 1956–April 1958, with a temporary rise to values around 10 s u during October–November 1957 A comparison of the mean level, 15 7 s u , for May–August 1958 (Fig 1*a*) with the corresponding level, 7 0 s u at Carmarthen in 1957[3] shows the extent to which the levels of strontium-90 increased in the pastures of this region between 1957 and 1958

Strontium-89 The occurrence of strontium-89 in milk, at levels such as those shown in Fig 1*b*, is a reflexion of recent weapons testing It will be noted that the November level is approximately three times higher than the mean summer level although there is no similar increase in strontium-90 levels This is due to the fact that strontium-89 present in deposited fission products is derived mainly from the tropospheric component of explosion debris, whereas, strontium-90 is mainly deposited from a stratospheric reservoir, depleted in strontium-89 by natural decay[4] The mean November 1958 strontium-89 value (310 $\mu\mu$c /gm calcium) is comparable with that found in October 1957 (280 $\mu\mu$c /gm calcium)[1]

The strontium-89/strontium-90 ratios are listed in Table 1 as average values for each month during October 1957 to February 1959 These values may be compared with the strontium-89/strontium-90 ratios, corrected to mid-month, reported by Stewart *et al* [5] for rain-water collected at Milford Haven, which lies 50 miles south-west from the centre of the Felinfach area This comparison shows that, during pasture feeding periods (Oct –Nov 1957 , May–Aug 1958) the monthly ratios for milk range from 46 to 86 per cent of the corresponding ratios for rain-water, the average value being 70 per cent This is consistent with the results of Bryant *et al* [6], who found strontium-89/strontium-90 ratios in herbage equal on average to 65 per cent of those in rain-water The strontium-89/strontium-90 ratios for radiostrontium in herbage and milk are smaller than the values in rain as a result of the mixing of current fall-out with earlier fall-out, depleted in strontium-89

Cæsium-137 On inspection of Figs 1*a* and *c*, it will be seen that the trend of cæsium-137 levels in these samples follows closely that of strontium-90 The cæsium-137/strontium-90 ratios throughout the year are similar to values obtained for samples produced prior to the Windscale accident This result confirms the suggestion made earlier[1] that cæsium-137, deposited on these pastures from the Windscale pile, is no longer being incorporated in the grass

The maximum error on cæsium-137/strontium-90 ratios, calculated from the values shown in Fig 1, is estimated to be ± 15 per cent The ratios (expressed as $\mu\mu$c cæsium-137/l /$\mu\mu$c strontium-90/l) range, for bulked samples, from 8 7 to 10 5 (mean value = 9 5) Within the limits of experimental error, the ratios may therefore be regarded as constant The weekly variations of cæsium-137 levels during May–August are shown in Fig 2, together with a breakdown of strontium-90 levels for the peak in June It appears from these results that for individual samples the cæsium-137/strontium-90 ratio varies to a small extent, but that in bulked samples, covering a period of a few weeks, the fluctuations tend to average out

As noted recently[7], a practical advantage would be gained if the comparatively straightforward estimation of cæsium-137 in milk could be used to provide an indirect estimate of strontium-90 It appears that, for the present series of samples, this approach would be reliable if supported from time to time by direct strontium-90 estimations It is possible, however, that the indirect estimations of strontium-90 could be misleading for samples derived

Table 1 Strontium-89/Strontium-90 Ratios in Milk (Felinfach)

Month	Strontium-89*/ strontium-90	Month	Strontium-89*/ strontium-90
1957		1958	
October	29 0	July	7 7
November	16 6	August	~ 8 7
December	5 8	September	~ 9 8
1958		October	—
January	3 7	November	18 8
February	2 5	December	11 0
March	3 4	1959	
April	5 8	January	6 7
May	7 2	February	4 9
June	7 2		

* Computed for each month from Figs 1*a* and *b* with due allowance for overlap of values for bulked samples and calendar months

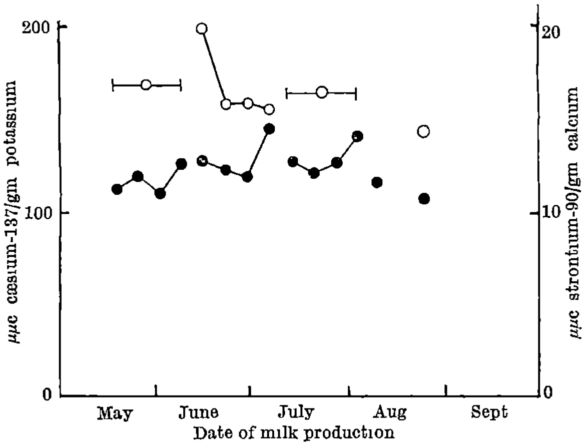

Fig 2 Cæsium-137 and strontium-90 levels in Felinfach milk during May to August 1958 ○, strontium-90 , ●, cæsium-137

from pastures which are more intensively cultivated than those in the Felinfach area[8]

Detailed accounts of the world-wide deposition of long-lived fission products have been published by Stewart *et al* [4,5,9], giving a continuous picture of the accumulation of these radionuclides on the ground In attempting to estimate the future trends of fission product-levels in milk it is important to know how far the levels are determined by the rate of deposition, on one hand, and the cumulative deposition, on the other Previous reports on milk produced in Great Britain suggest that the levels of both strontium-90 and cæsium-137 depend more on the rate of fall-out than on total deposition[1,3,10] The present results throw further light on this complex question

The most recent report by Stewart *et al* [5] shows that the rate of deposition in Great Britain during the summer of 1958 was considerably greater than during previous summers It appears further that this increase was due in substantial measure to the occurrence of unusually high summer rains Using the values reported for specific activity in rain-water at Milford Haven, together with information on the rainfall at six meteorological stations in the Felinfach–Carmarthen area, we estimate that the average total strontium-90 fallout in this region for May–August 1958 was 2 8 times the corresponding value for 1957 A similar estimation shows that the cumulative total rose between June 1957 and June 1958 by a factor of 1 5 The results for strontium-90 in Felinfach–Carmarthen milk provide firm evidence that the average level during May–August 1958 was approximately double the corresponding 1957 level (comparing 15 7 S U , 1958, with 7 0 S U , 1957, gives a factor of 2 2) It will be seen from these figures that the increased levels in milk could be fully accounted for by the increased rate of fall-out, although an appreciable dependence on the cumulative total cannot be excluded Further information on the relative importance of these different factors is given by the strontium-89 results, as discussed below

It is not clearly known what fraction of the strontium-90 present in herbage enters the plant by direct uptake through leaves and stem, as opposed to entry from the soil via the root system[8,10] It appears that a large fraction of the strontium-90 deposited on the ground is retained by many soil types in the top few inches of the soil, but again it is not clear what fraction of the cumulative activity is available to the plant The present results show that the strontium-89/strontium-90 ratios in milk, produced during pasture-feeding periods, are on average at least 70 per cent of the values which would occur in the herbage if there was no contribution from the soil reservoir The ratios in milk during May–August 1958 are approximately five times the corresponding ratios for the cumulative totals of strontium-89 and strontium-90 in the soil[5] A simple calculation based on these results shows that less than 35 per cent (that is, 5 5 S U) of the strontium-90 in the milk produced during May–August 1958 may be derived from the cumulative deposit in the soil The results do not preclude the possibility that all the radiostrontium enters the herbage via the soil but, on that basis, only the deposit of the preceding 4–5 months would be involved It follows from these arguments that the 1958 increase of strontium-90 levels in the Felinfach samples is related mainly to the corresponding increase in fall-out rate Consequently the rise in levels should be regarded in terms of a fluctuation rather than an increase to higher stable levels

The striking parallel in the trends of strontium-90 and cæsium-137 (Fig 1) strongly suggests that rate of fall-out is equally important for both nuclides This result is in keeping with previous indications of the importance of fall-out rate in the case of cæsium-137 levels in milk sampled both in Great Britain[2] and the United States[11] Reports on the trend of strontium-90 levels in milk produced in the United States have tended to link the levels with the cumulative fall-out[12,13,14] It is clear, however, that comparatively large, short-term fluctuations, indicative of a high dependence on fall-out rate, have occurred in these levels[14]

It is not possible to forecast accurately the levels of strontium-90 and cæsium-137 which will occur in milk during the current year, since neither the 1959 rainfall nor the influence of the 1958 series of weapons tests on the specific activity of the rain can be exactly predicted Provided that no further testing occurs, the levels of strontium-89 in milk produced after the summer of 1959 might be expected to be less than one-tenth of the levels occurring during November 1958

We wish to acknowledge our indebtedness to Prof. W V Mayneord, director of the Physics Department, Institute of Cancer Research (Royal Cancer Hospital), for his guidance and encouragement throughout these studies

The studies were supported by grants from the Medical Research Council

[1] Mayneord, W V , Anderson, W , Bentley, R E , Burton, L K , Crookall, J O , and Trott, N G , *Nature*, 182, 1473 (1958)

[2] Booker, D V , *Nature*, 183, 924 (1959)

[3] Bryant, F J , Morgan, A , and Spicer, G S , Atomic Energy Research Establishment, Harwell, *HP/R* 2730 (1958)

[4] Stewart, N G , Osmond, R G D , Crooks, R N , and Fisher, E M , Atomic Energy Research Establishment, Harwell, *HP/R* 2354 (1957)

[5] Stewart, N G , Osmond, R G D , Crooks, R N , Fisher, E M R , and Owers, M J , Atomic Energy Research Establishment, Harwell, *HP/R* 2790 (1959)

[6] Bryant, F J , Chamberlain, A C , Morgan, A , and Spicer, G S , *J Nuc Energy*, 6, 22 (1957)

[7] Low, K , and Edvarson, K , *Nature*, 183, 1104 (1959)

[8] Scott Russell, R , *Nature*, 182, 834 (1958)

[9] Stewart, N G , Crooks, R N , and Fisher, E M R , Atomic Energy Research Establishment, Harwell, *HP/R* 2017 (1957)

[10] Marley, W G , Symposium on Noxious Effects of Low Level Radiation, Lausanne, 348 (Schwabe, Basle, 1958)

[11] Anderson, E C , *Science*, 128, 882 (1958)

[12] Eisenbud, M , Hearings of the Joint Committee on Atomic Energy, Congress of the United States, 554 (Government Printing Office, Washington, D C , 1957)

[13] Eckelmann, W R , Kulp, J L , and Schulert, A R , *Science*, 127, 266 (1958)

[14] Libby, W F , Symposium on Noxious Effects of Low Level Radiation, Lausanne, 309 (Schwabe, Basle, 1958)

OBITUARIES

Mr. R P Howgrave-Graham

By the death on March 25 in his seventy-ninth year of Robert Pickersgill Howgrave-Graham, a remarkable life devoted to such varied subjects as electrical science, horology and archæology was brought to its close

Howgrave-Graham was born in Hampstead into a cultured family His father was the first secretary of the Institute, now the Chartered Institute, of Patent Agents

During 1896–99 Howgrave-Graham studied electrical engineering at Finsbury Technical College under Silvanus Thompson, whom he revered throughout his life as his teacher and his friend Appointed a demonstrator upon the completion of his course, Howgrave-Graham began to assist Silvanus Thompson in his researches, to undertake teaching duties, and to experiment with Herzian waves and high-frequency electric currents He showed himself to be an exceptionally lucid, sympathetic and enthusiastic teacher and an experimentalist of high ability

In the years prior to the First World War, Howgrave-Graham was associated with Lodge and Muirhead in the perfection of the wheel coherer, and he devised during the same period a reed, or fork-maintained, phonic motor of relatively high power During the War, Howgrave-Graham, who was not physically fit for active service, continued his teaching at Finsbury and engaged in various research projects for the Fighting Services The sudden death in 1916 of Silvanus Thompson left him to carry on, practically single-handed, the teaching of physics and electrical engineering at Finsbury

In 1919, Howgrave-Graham left the Finsbury Technical College and took up a similar lectureship at the Northampton Polytechnic, where he continued his teaching work until his retirement in 1945

Within a few months of the end of the First World War, Howgrave-Graham became engaged in the important patent action resulting from the application of Fleming and the Marconi Company for an extension of the term of Fleming's main thermionic diode patent of 1904 He gave evidence in support of the De Forest Company

Although a teacher of distinction and a contributor to the early development of wireless telegraphy, Howgrave-Graham's best-known work is not in the field of electrical engineering but in that of archæology He became an acknowledged expert on medieval machinery and in particular on church clocks His two greatest works in this field were his researches associated with the restoration of the Wells clock, now in the Science Museum, and the Salisbury clock, which was reinstated in the Cathedral in 1956 Howgrave-Graham's patient and accurate historical research on these clocks, which not only contributed notably to their restoration but also incidentally established their dates at 1392 and 1386, respectively, was a work of real scholarship

Photography was, for him, handmaiden to archæology The art of photographing the interesting and beautiful features of the architecture of medieval buildings was one at which he excelled and many of his photographs, some of striking beauty, have been reproduced in books on Gothic art

Happily for him, retirement from teaching presented a unique opportunity to devote himself single-mindedly to his archæology He was appointed as assistant keeper of the muniments at Westminster Abbey There he carried out much skilful restoration work, including the reinstatement and preservation of the earlier funeral effigies which had suffered severe damage by water during an incendiary bomb attack His work on the effigies of Edward III and Henry VII revealed that the features of these effigies were actual death masks

Quiet, kindly and sensitive, Howgrave-Graham was endowed with courage and perseverance and above all with the spirit of inquiry There was, however, something more which made him the delightful and lovable character which he was He enjoyed sharing his discoveries, he had a keen sense of humour and he never took himself too seriously Howgrave-Graham's sense of humour was part and parcel of his feeling for the quaint and the incongruous Perhaps that is why he was so much in tune with the touches of humour of the medieval illuminator or stone mason

Howgrave-Graham married in 1944 Miss Beatrice Purdy, who survives him J Greig

Dr W A Hargreaves

Dr William Arthur Hargreaves died at Adelaide on March 31 in his ninety-third year After an outstanding scholastic career in the University of Melbourne, where he took degrees in arts, science and civil engineering, Hargreaves occupied a number of teaching positions in Victoria and Queensland between 1889 and 1916, when he was appointed director of the Department of Chemistry and Government Analyst for South Australia, a position he occupied until his retirement in 1932

Although Hargreaves was an outstanding analyst and a capable research worker (he was awarded the D Sc of the University of Adelaide in 1916) his greatest contributions to chemistry in Australia arose out of his interest in the teaching of the subject and the part he played in the formation of societies for the promotion of the profession He was a member of the Faculty of Science of the University of Adelaide for thirty-one years and served also on the Australian National Research Council and the Council of the South Australian School of Mines He was an executive officer of the Society of Chemical Industry of South Australia throughout its short life (1915–19) and a foundation member of the Royal Australian Chemical Institute, of which he was president during 1919–21

Outside his profession, Hargreaves's greatest interest was in motoring , he was the first person in Australia to obtain a driving licence and the first to register a motor-car in South Australia, holding the number plate S A 1 from 1906 until 1955 In 1894, he married Camilla Maud Nicholls, of Melbourne, by whom he had a daughter Both his wife and daughter predeceased him Harold J Rodda

NEWS and VIEWS

Psychology at Sheffield

Dr H. Kay

Dr. H. Kay, at present lecturer in experimental psychology at Oxford, has been appointed to the newly established chair of psychology at Sheffield. Dr. Kay read psychology after the English Tripos at Cambridge and for a number of years worked in the Nuffield Unit for research into problems of ageing at the Psychological Laboratory there. During this time, he gained considerable experience of the application of experimental methods to the investigation of manual and other skills. He also took part in field work undertaken by the Unit and was a member of the Naval Medical Expedition to the Arctic in 1949. In 1951, he was appointed to his present Oxford post and played a large part in the development of the Honour School of Psychology, Philosophy and Physiology which was taking place at that time. During the period 1953–56 he led a small team with outstanding success in research sponsored by the Conditional Aid Programme into the fundamentals of industrial skills. He and his colleagues have since extended this work in fruitful directions. Dr. Kay recently spent a year at the National Institutes of Health, Bethesda. During his years at Oxford, Dr. Kay has been active not only in university but also in college teaching, and has latterly been tutor in psychology at Balliol and Merton.

Electrical Engineering in the University of Western Australia :

Prof. A. R. Billings

Dr. A. R. Billings, who has been appointed professor of electrical engineering in the University of Western Australia, graduated from the University of London in 1949, taking his Ph.D. degree in 1957. During 1951–52 he worked as a scientific officer in the Royal Naval Scientific Service before being appointed lecturer in electrical engineering (electronics and communications) in the University of Bristol. His principal interests are in the band-width compression of speech, and in the less usual applications of semiconductors. His earlier work in the first field has resulted in the production of a vocoder which is both simpler and more efficient than the conventional vocoders; while his later work has been concerned with the development of a formant tracker, and a simple synthesizer to go with it. In the semiconductor field Dr. Billings's main interest has been in application of the Hall effect in the new semiconductor compounds. This has resulted in the production of a suppressed-carrier modulator with very low carrier leak, and of a Hall-effect correlator which, when used in conjunction with the early vocoder, has provided new information about the properties of speech.

The chair of electrical engineering in the University of Western Australia is newly established, and Dr. Billings will be the first holder. The research in which he has been engaged is individual work which can be carried on with small-scale apparatus, and he will take with him to Australia some of his equipment from Bristol.

Rockefeller Foundation Grants to C.S.I.R.O. (Australia)

The Australian Commonwealth Scientific and Industrial Research Organization has formed a new Division of Tropical Pastures with headquarters in Brisbane. Dr. J. Griffiths Davies, associate chief of the C.S.I.R.O. Division of Plant Industry and officer-in-charge of the Organization's Plant and Soils Laboratory, Brisbane, has been appointed first chief of the new Division, which will continue to work in association with its parent C.S.I.R.O. Division of Plant Industry. Establishment of the Division of Tropical Pastures reflects the Organization's appreciation of the importance of developing pastures in the summer rainfall areas of Australia, and of the scientific standing of the Brisbane group.

The Rockefeller Foundation has given 30,000 dollars for special equipment for the newly formed Division. The grant will help equip the new Cunningham Laboratory, which is nearing completion. The new laboratory is next to the University of Queensland at St. Lucia, near Brisbane, and will be the headquarters of the C.S.I.R.O. Division of Tropical Pastures. The Division will use its grant to purchase a mass spectrometer and equipment for work with radioactive isotopes. These will be used to expand the Division's work on nitrogen and phosphorus, which are the most important deficiencies in Queensland soils. Dr. J. G. Davies expects that research will make possible a great increase in the carrying capacity of Queensland's pastoral areas.

This is the third large grant that C.S.I.R.O. has received from the Rockefeller Foundation in recent years. Recently the Rockefeller Foundation gave 100,000 dollars for special equipment for the Organization's Divisions of Plant Industry and of Entomology at Canberra. The Foundation also provided 250,000 dollars towards the cost of the giant radio telescope which will soon be constructed at Parkes, New South Wales, for the C.S.I.R.O. Division of Radiophysics.

Radio Telescope for Australia

It has been announced that the contract for the Commonwealth Scientific and Industrial Research Organization's giant radio telescope, which is to be located at Parkes, New South Wales, has been placed with the German firm of Maschinenfabrik Augsburg–Nuernberg A.G. Dr. E. G. Bowen, chief of the Organization's Division of Radiophysics, has played a leading part in completing the design of the radio telescope. It is expected that the total cost of the project will not be far short of £A750,000. Donations towards this have already come from the United States (from the Rockefeller Foundation and the Carnegie Corporation) and from industry and from private donors in Australia. Work to prepare the site is already in hand, and a start will be made to erect the telescope about the middle of 1960. A feature of the telescope will be its radio 'mirror', a saucer-shaped bowl 210 ft. in diameter and covered in wire mesh. This 'mirror' will pick up radio signals from the outermost fringes of the universe It will be slightly smaller than that of the only other giant radio telescope at present in existence (at Jodrell Bank, England) However, the surface accuracy of the Australian radio telescope and the precision with which it can be pointed and driven will all be substantially higher

Proton Linear Accelerator

THE 50 million electron volt proton linear accelerator at the Rutherford High Energy Laboratory, Harwell, came into operation on July 12 This is the first accelerator at the National Institute for Research in Nuclear Science to come into operation It will be used for nuclear research by physicists from universities, the Atomic Energy Authority and a resident team based at the Rutherford Laboratory When in full operation it is expected to have a proton beam intensity many times greater than other accelerators of this kind Because of the high intensity and very well-defined energy it will be possible to do experiments of great value in the study of the interaction between nuclear particles The main parts of the accelerator were designed and constructed for the Atomic Energy Authority by Metropolitan Vickers, Ltd , in collaboration with a team of physicists and engineers from the Atomic Energy Research Establishment who also carried out basic development work on the accelerating structures, and were responsible for the other parts of the machine

High-Pressure Oxygen and Radiotherapy

IT is now well established that when certain cells are deprived of oxygen they become more radio-resistant, and recent work has demonstrated a similar effect upon malignant cells Thomlinson furthermore suggested that in some malignant tumours a proportion of the cells were deficient in oxygen, due essentially to an inadequate local circulation, which could lower their radiosensitivity On this basis, Dr I Churchill-Davidson, Dr C Sanger and Dr R H Thomlinson started in 1954 at the Radiotherapy Department of St Thomas's Hospital a preliminary investigation of the effects of irradiating certain malignant tumours in patients breathing 15–20 times the normal amount of oxygen while in a pressure chamber, which had been designed and presented by Sir Robert H Davis To obtain adequate irradiation at a depth without severe skin damage, γ-rays from a cobalt teletherapy unit were used

Preliminary results in the treatment of advanced carcinomas were encouraging, and in order to try to overcome the limitations of the early prototype apparatus a new unit, specially designed for this purpose, has recently been installed at St Thomas's Hospital Essentially, the unit consists of an aluminium pressure chamber, also presented by Sir Robert Davis, into which are led oxygen pipes and multiple leads which enable the patient to be kept under controlled anæsthesia and observed electronically, although not seen, during treatment A twin-headed cobalt-60 teletherapy unit has also been installed with this chamber, so designed in order to reduce the time of treatment to a minimum

River Purification

THE growth of population and industry has produced problems of river management which had not been foreseen and are not capable of immediate solution Many of the worst cases in Britain are in areas where industry developed and population grew rapidly between 1750 and 1850 , the seriousness of the problem was not appreciated until it had reduced many of the rivers to an appalling condition It was, however, a very long time before it was appreciated that the effects of modern developments in industry and in urbanization on surface waters must be taken into account when plans for the future are being made Even as late as the 1920's the establishment of the beet sugar industry in Britain gave rise to an alarming pollution problem which threatened to turn many of the rivers in our rural areas into a condition as foul and offensive as those in the old industrial areas About the same time, the growth of road transport led to the use of tar as a surfacing material for roads and that gave rise quite unexpectedly to a pollution problem which could have had serious effects on fisheries had it not been tackled in time From then on it began to be realized that the prevention of pollution was, in fact, a practicable proposition and was possible if those concerned, whether industry, local authority or river authority, appreciated the problems and discussed them with other water interests before the waste waters had to be discharged Eventually, this arrangement became an integral part of the Rivers (Prevention of Pollution) Act, 1951, which provides that the consent of a river board is necessary to any new discharge made into non-tidal waters According to F T K Pentelow, of the Fisheries Department, Ministry of Agriculture, Fisheries and Food (*Science Progress*, 47, No 185 , January 1959), that change of policy seems to be having good results, for the very considerable industrial expansion which has occurred since the War has not, so far, given rise to pollution problems on anything like the scale it would have done one hundred years ago

Federation of British Industries

IN the forty-second annual report of the Federation of British Industries for 1958 (pp vi+42 London Federation of British Industries, 1959) it is stated that the gradual discontinuance of research on defence projects sponsored by Government departments has necessitated a fundamental appraisal of the future finance and organization of industrial research Discussions at the National Production Advisory Council on Industry showed that the Government's plans put forward by the office of the Lord President of the Council required a detailed statement of industry's point of view The Federation's Industrial Research Committee has already formulated an interim statement, which was submitted to the Advisory Council in June 1958, and is now undertaking a detailed study of certain aspects of British research practice in relation to methods adopted abroad The report also notes the establishment by the Federation's Education Committee, in co-operation with representatives of the Publishers' Association, Aslib the universities and the technical colleges, of a panel to investigate the alleged shortage of advanced British text-books

Technological Education in Britain

THE tenth annual report of the London and Home Counties Regional Advisory Council for Technological Education (pp 28 London, 1958) covers the year ended August 31, 1958, and refers to a complete reorganization of the Council Under its new constitution, the approval of location of courses under the Ministry of Education's Administrative Memorandum 545 will be carried out by the Distribution of

Courses Committee, and a sub-committee of this committee, which considered the future development of the Council's work, recommended that the help of advisory committees should be sought in considering what advanced educational facilities are required for specific industries and in suggesting future distribution of courses A committee has been formed to consider the relation of the universities with the technical colleges The regional academic board arranged a very successful one-day conference on "Science and the Nation the Role of the Grammar Schools and the Technical Colleges" Of the 141 courses approved to start in 1958–59, 14 were in applied science and mathematics, and 74 in engineering , of the total, 36 were full-time and sandwich courses

Smithsonian Publications

A list of Smithsonian Publications available for distribution on June 30, 1958, has been compiled by Eileen M McCarthy (pp vi+54 Washington, D C Smithsonian Institution, 1958) The papers are distributed gratis, except where price is given, to applicants requiring the papers as an aid to their researches or studies Justification is required if more than one copy each of ten publications is requested, and requests should be addressed to the Publications Distribution Section, Editorial and Publications Division, Smithsonian Institution, quoting the publication numbers in sequence The publications are listed under some sixty-four subject headings, arranged alphabetically

Pharmacy as a Career

The latest booklet in the choice of careers series issued by the Central Youth Employment Executive (H M S O , 9*d*) describes the work of pharmacists in each branch of practice and indicates the qualities needed for the profession , information is also given about the educational qualifications and training required The purpose of the booklet is to help boys and girls to decide whether they are likely to find a satisfactory career in this profession , in most cases the decision as to which branch of practice students should follow is best left until they have gone at least some way with their training and can properly appreciate the relative attractions of the various branches in which they can later specialize

Institute of Physics "Notes for Authors"

The Institute of Physics has recently published a revised edition of its 36-page booklet to assist authors and to serve as a work of reference for all those who wish to contribute to the Institute's publications Under its new title, "Notes for Authors", it gives hints on the preparation of scripts and diagrams, on the layout of mathematics, the correction of proofs, and so on In addition to a bibliography of reference books and works on technical writing, the pamphlet also contains lists of the spellings, symbols and abbreviations used by the Institute Copies of this booklet are obtainable from the Institute of Physics, 47 Belgrave Square, London, S W 1, price 3*s* 6*d*

U S National Academy of Sciences Foreign Associates

The following have been elected foreign associates of the U S National Academy of Sciences Dr V A Ambartsumian, director of the Burakan Observatory in Erevan, Soviet Armenia , Sir Edward Bullard, assistant director of research in the Department of Geodesy and Geophysics, University of Cambridge , Prof Max Hartmann, Max Planck-Institut fur Biologie, Tubingen , Sir William Hodge, Lowndean professor of astronomy and geometry, University of Cambridge

Birbal Sahni Memorial Medal

The Birbal Sahni Medal for 1958 has been awarded to Prof P Maheshwari, professor of botany in the University of Delhi This Medal was instituted by the Indian Botanical Society through a generous grant of 2,500 rupees made by Prof T S Sadasivan of Madras in 1957 to commemorate the memory of the late Prof Birbal Sahni It is awarded every year to a distinguished Indian botanist for his contributions and services to botany in India The first medal (for 1957) was awarded to Prof M O P Iyyengar

United Steel Companies, Ltd Research Department

Dr K J Irvine has been appointed deputy research manager of the United Steel Companies, Ltd He has relinquished his present duties as head of the metallurgy section, which is to be reconstituted Mr J D Murray has been appointed head of a new section to be known as applied metallurgy, which embraces high-temperature metals, alloy development and welding Mr F B Pickering has become head of another new section on physical metallurgy, which deals with the more fundamental aspects of this subject

Announcements

Sir John Russell, formerly director of the Rothamsted Experimental Station, has been elected a member of the Polish Academy of Sciences

Dr D J Price has been appointed visiting professor of the history of science in Yale University for the academic year 1959–60 During the past year Dr Price has been John W Donaldson Fellow and member of the School of Historical Studies at the Institute for Advanced Study, Princeton, New Jersey

Mr Gwilym Hughes has been appointed to succeed Mr Donald Hudson as president of the Pharmaceutical Society of Great Britain , and Mr Tom Reid becomes vice-president in succession to Mr Hughes Mr W Spencer Howells is treasurer for the thirteenth successive year

The Royal Society of Edinburgh, 22 George Street, Edinburgh 2, has arranged to microfilm the thirteen volumes of the David Hume manuscripts Copies of the microfilm will be available by purchase only, and libraries interested are invited to send forward their names, when further particulars will be circulated

The Journées Métallurgiques d'Automne of the Société Française de Métallurgie will be held in Paris during October 19–24 The subject is "Les Gaz dans les Métaux" Further information can be obtained from the Société Française de Métallurgie, 25 Rue de Clichy, Paris 9e

Erratum Dr G Di Sabato writes "In my communication entitled 'Effect of Reduced Diphosphopyridine Nucleotide on the Swelling of Isolated Mitochondria', published in *Nature* for April 4, p 997, column 2, 'sucrose 690 μmoles' in line 6 should be 'sucrose 1,200 μmoles', and '180 μmoles' in line 8 should be '18 μmoles' "

THE GRADUATE SCHOOL IN MATHEMATICAL PHYSICS AT BIRMINGHAM

IN 1956, a Graduate School in Mathematical Physics, leading to a diploma, was instituted in the Department of Mathematical Physics of the University of Birmingham It had been noticed that students who graduated in the honours school of mathematical physics in the Department seemed well equipped, and considerably in demand, for work involving the applications of mathematics to physical problems in industry, government laboratories, etc , because of the training they received in the principles of physics, and particularly in the techniques of translating physical problems into mathematical terms, and of interpreting the solutions from a physical point of view

Entry to the honours course at Birmingham is restricted to students of high ability, who must have the appropriate background in their school training, since the three-year course makes fairly heavy demands on the students It seemed likely therefore that a one-year postgraduate course would be of advantage to students who had taken a degree in mathematics, because they could not—or did not choose to—enter the mathematical physics course, or who graduated from universities at which such a course was not available

The three years of operation of the Graduate School have provided sufficient experience to judge that it can serve the purpose for which it was intended, and that it imparts to the students knowledge and experience which serves them well in their later work The course extends over one academic year (October to July) and is normally intended for honours graduates in mathematics with subsidiary physics In some cases it proved possible to fit in students with somewhat different qualifications Lecture courses attended by the students include a course in methods of mathematical physics (given so far by Dr J G Valatin, who is in general charge of the Graduate School), which forms the central theme of their introduction to the outlook of a mathematical physicist In addition, students normally take selected parts of the lecture courses for honours physicists, and those parts of the final-year course for mathematical physicists (electromagnetic theory, hydrodynamics, quantum mechanics) which they have not previously covered, and which suit their particular needs Other options include mathematical statistics, numerical methods, elasticity theory, statistical mechanics, and usually at least one course in one of the applied science departments All students attend a weekly seminar arranged specially for the Graduate School in which they contribute themselves, and otherwise hear talks by members of the research group in mathematical physics and others It has proved possible to arrange for each individual student a combination of courses which suits his particular interests and knowledge

Although many of these courses are given for other purposes, students find it easy to synthesize their work and to build them into a common foundation of understanding

The number of students in the course has remained small in the first three years, and is likely to continue small until the existence and purpose of the course become more widely known It is therefore premature to give any statistics of the subsequent occupations of students who have obtained the diploma These included work in industry and government laboratories as well as academic research (One student took up postgraduate work in the Mathematical Physics Department at Birmingham, and two joined an applied science department in the University)

The development of the Graduate School was greatly aided by the award of advanced course studentships of the Department of Scientific and Industrial Research, and in some cases by grants from the University of Birmingham

R E PEIERLS

WATER-RESOURCES AND WATER-USE SURVEY

THE study of the use and conservation of water resources is a relatively new geophysical science and one that impinges closely on other sciences such as meteorology and climatology, geology and geomorphology, agriculture, economic geography, demography, etc The importance in the modern world of economic and land-use planning, particularly with reference to so precious a raw material as water, involves the collection of a vast and varied amount of data and information relevant to the assessment of water resources, on not only a national but also an international basis Two papers*, published by the World Meteorological Organization, are useful statements in this important field, particularly in view of the varying scientific standards of recording and observation that are available and possible in different world regions

M A Kohler summarizes briefly the types of hydrological data, the network density of observations required, and network planning, and the techniques for estimating hydrological data that can be used Attention is directed to the impracticability of devising a universally standardized procedure and a scheme is put forward for the creation of a minimum cover of permanent full, partial, and temporary observational stations

The second, longer, technical paper is more closely concerned with techniques for the surveying of surface water resources in a region, and providing estimates of usable water supply. Attention is given to methods which are adapted for use in the absence of adequate hydrological data and to simple techniques of observing hydrological phenomena which may provide useful data with least cost in time and money. Despite the importance of ground-water circulation in all regions—and especially in arid regions—the survey is limited to the discussion of techniques with regard to surface resources. These are a guide to the estimation of requisite rates of replenishment of ground water that are necessary for the effective use of the latter over a period of time. The main topics discussed are the hydrological balance, precipitation, evapotranspiration and its measurement, stream-flow, sediment transport and water supply, and a summary direction for procedure in the matter of water-resource surveys.

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* World Meteorological Organization Technical Note No 25 Design of Hydrological Networks Prepared by Max A Kohler Technical Note No 26 Techniques for Surveying Surface-Water Resources Prepared by Prof Ray K Linsley Pp v+16+xi+41 (WHI-No 82 TP 32) (Geneva Secretariat of the World Health Organization, 1958) 4 Swiss francs

The special problems and peculiar needs of a densely populated and highly industrialized country such as Great Britain are summarized in an interesting discussion on a water-use survey opened by Prof. W. G. V. Balchin (under the chairmanship of Prof. Dudley Stamp), with contributions from experts representing a very wide range of technical interests in this important field (*Geog. J.*, 124, 476, 1958). Prof. Balchin directs attention to the dramatic increases in water consumption in Britain during the past century, culminating in an increase of 50 per cent in England and Wales and 41 per cent in Scotland during the short period 1938–56. The water storage capacity in the same time has increased by only 46 per cent and 31 per cent, respectively. The area where the consumption is greatest is the area where population is densest and the rainfall least, and where the local resources are already fully employed—that is, in lowland Britain and particularly in the great urban and industrial complexes.

These papers are a salutary reminder, through the many facets to the problem of water conservation that they reveal, of our ultimate dependence on water resources and our need to avoid over-exploitation of a raw material that, in Great Britain at least, people assume all too readily is in abundant supply, and for which in many others the supply is already precarious. ALICE GARNETT

CARNEGIE TRUST FOR THE UNIVERSITIES OF SCOTLAND

THE fifty-seventh annual report of the Executive Committee of the Carnegie Trust for the Universities of Scotland covers the year 1957–58 (pp. iv+74. Edinburgh: Carnegie Trust for the Universities of Scotland, 1959) and includes the financial accounts for the year ended September 30, 1958. A major preoccupation of the Executive Committee during the year was the formulation of a policy to implement its new powers of investment. During the year there were on the books five senior research scholars, thirty-six research scholars in their second or third year, and twenty-five in their first year. For 1958–59 the value of the senior scholarship has been increased to £500 (with an additional £100 for expenses), while scholars at Oxford, Cambridge and London will receive £450; scholars living away from home, attending a Scottish or an English provincial university, £400; and scholars living at home and attending a Scottish university, £350. A grant of £4,000 a year for five years from the end of 1958 was made to the Scottish Dictionaries Joint Council, subject to some conditions with regard to progress. Ten of the research grants awarded during the year were for expenses involved in illustrating the published results of research and five grants were made to authors as a subvention towards the cost of publishing their books.

Four grants are particularly mentioned. The Trust has provided a special heavy-duty vehicle and a 'Folboat' with outboard motor and a grant for running expenses to assist Prof. J. H. Burnett and Dr. D. H. N. Spence, of the University of St. Andrews, in preparing a comprehensive account of the aquatic vegetation of Scotland, a research which involves crossing many moorland roads to examine distant mountain lochs. A grant of £2,500 was made to Prof. R. H. Matthew, of the University of Edinburgh, for a study by a research team correlating the problems of the design of basic dwelling units, lay-out, siting and services with social requirements, with specific reference to contrasting types of social grouping and including a cost study. Another grant was to the University of Glasgow North Rona Expedition, which spent about a month on North Rona and Sula Sgeir, paying particular attention to marine biology. Some very rare species of algae were found and a special census was made of Leech's petrel. A second successful expedition, assisted by a grant from the Trust, was one from the University of Aberdeen, led by Prof. A. C. O'Dell, to St. Ninian's Isle, Shetland, in June–July 1958, in which a most important collection of silver ornaments was uncovered.

Of the ten grants for travel and maintenance made to members of university staffs engaged in research, three were to members of a faculty of medicine, four in science and three in arts. Among these may be mentioned those to Dr. W. I. Card to enable him to visit centres in the United States and Canada, where work of interest and importance in gastroenterology is proceeding; to Mr. Alastair Fraser, to work in Copenhagen in the laboratories of Prof. M. Thomsen and Dr. E. Thomsen, leading authorities on insect endocrinology, and later in Liège, Brussels and Paris; to Dr. C. H. Gimingham to enable him to follow up in Scandinavia his investigations in Scottish heaths, aimed at gaining a comprehensive picture of the ecology of heather, including its reactions to grazing and burning and influences of soil climate and at utilizing this information in an investigation of the ways in which heath lands have originated and are maintained; to Dr. Elizabeth D. Fraser, to enable her to test in America some of her hypotheses regarding perceptual constancy as a function of personality and learning and the effect of metabolic disturbance; and to Dr. P. H. Tuft, to discuss his experimental techniques in embryology in the United States.

THE SCHOOL HEALTH SERVICE IN BRITAIN

THE School Health Service is fifty years old In the half-century of its existence there have been remarkable changes in the health of school children, and in the pattern of illnesses affecting them Both boys and girls to-day are taller and heavier, better clad, better shod and cleaner They reach physical maturity earlier and may expect to live twenty years longer In sharp contrast to the conditions of malnutrition found only too commonly 50 years ago, medical attention is now being drawn towards an increasing number of school children who are too fat

The annual report* of the Chief Medical Officer presents these facts and discloses among other vital statistics that the killing and crippling diseases prevalent at the turn of the century—tuberculosis, rickets and rheumatism—have been practically eliminated The remaining causes of crippling and other forms of handicap are now mainly congenital or hereditary in origin Accidents still kill twice as many children as die from disease, and road accidents are responsible for half the deaths recorded Boys are more liable to death on the road than girls , leaving school in the afternoon is one of the most risky periods of the day

Nearly 250,000 children were found to have verminous heads in 1957 This is about 4 per cent of the total school population "This condition is preventable and there is seldom any excuse for it", says the report "It is essentially a family problem, children being infested and re-infested by adults" The current question of smoking and its relation to lung cancer provides "a striking example of the need for boys and girls, while still at school, to be taught something about healthy living—by example, perhaps, more than by precept In spite of all that has been said and written about the close connexion between the two, many children still smoke cigarettes" A recent inquiry carried out at a mixed secondary modern school in the Isle of Wight disclosed that about a third of the boys and 15 per cent of the girls were regular smokers

The incidence of dental decay has increased in the past few years among school children, and is due "probably to the greater amount of sweets and confectionery eaten since the end of sweet rationing" Fluoridation of water supplies probably offers the best hope of reducing this incidence, "but large scale benefits from this measure can hardly be expected for several years"

One consequence of the changing pattern of ill-health in childhood is that school health service staffs now devote more attention to children who are emotionally disturbed, or who suffer from some handicap which threatens to have a retarding effect on school progress from a psychological cause

There is also the challenge of the delinquent school child which cannot be ignored by the school health service The number of children charged before the juvenile courts has risen from 13,000 in 1913 to 38,000 in 1956 It is right, says the report, that the school health service should concern itself with the problem and co-operate with the other agencies involved In 1957 more than six and a half million children attending about 30,000 maintained and assisted schools were covered by the service More than two million have a periodical inspection during the year

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* The Health of the School Child Fifty Years of the School Health Service (Report of the Chief Medical Officer of the Ministry of Education for the years 1956 and 1957) Pp i+220+12 plates (London H M Stationery Office, 1958) 10*s* 6*d* net

INCENTIVES IN THE BUILDING INDUSTRY

A RECENT Building Research Station report* on incentives in the building industry shows that bonus schemes have an important contribution to make to building efficiency The maximum benefit can only be derived, however, if they are integrated into a rational pattern of management The report enumerates principles on which an incentive scheme should be based as well as the method of operation if it is to be successful

Operation targets, coupled with a recording system giving operation costs, should be used whenever possible The operations should be the visual stages of work, of about one week's duration, and continuous jobs with no hold-ups for other trades

The scheme should be designed to suit individual needs and local conditions This calls for flexibility in targets to suit the local productivity of labour and the distribution of bonus payments The operatives on each site should decide the method of sharing within the bonus group or gang It is necessary to safeguard the quality of work by making site staff independent of production bonus and improving site supervision of quality

A number of conclusions were reached about the methods of operation of an incentive scheme Accurate and well-balanced targets should be maintained by the systematic use of cost information from all the firm's sites and by close consultation with its site staff The incentive effect of a scheme is greatest when it is given a central position in the organization of the firm, especially if administered by the contract management side There should be close liaison between estimating and the fixing of target bonus-rates The principles of the scheme should be kept simple and explained to the operatives so that they can calculate their own bonuses. The bonus units are small gangs

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* Department of Scientific and Industrial Research Building Research Station National Building Studies Special Report No 28 Incentives in the Building Industry By Alison Entwistle and W J Reiners Pp iv+43 (London H M Stationery Office, 1958) 3*s* net

The bonus paid should be the actual amount of bonus earned; there should be no limit to the amount of bonus that can be earned; the bonus should be paid weekly and as soon as possible after the completion of the operation. The scheme should cover, so far as possible, all the work on the site. Good labour relations on the site are an aid to productivity and should be encouraged by presenting the targets to the operatives for agreement before work starts and a recognized channel for complaint should be established. Provision should be made to allow targets to be modified on a particular site if adequate reason is established. Disputes or complaints should be dealt with speedily and in consultation with the site staff.

SURFACE OF THE OCEAN AS A SOURCE OF AIR-BORNE NITROGENOUS MATERIAL AND OTHER PLANT NUTRIENTS

By Dr. A. T. WILSON

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IN an earlier communication[1] the occurrence of organic nitrogen in New Zealand snows was reported, and it was suggested that this might represent a contribution to the nitrogen economy of New Zealand soils. This article presents further results on the subject and points to the most probable origin of this air-borne nitrogenous material.

Samples of snow have been collected from above the vegetation line to avoid possibility of contamination by plant or animal debris. This was done in preference to the more conventional rain-water sampling which is open to large contamination errors. The analyses[2] of these samples are shown in Table 1.

Since the samples described here were freshly collected snow from regions where no plants or animals exist, contamination from these sources should be negligible. No insoluble inorganic material was visible in the samples, so that cyclic terrestrial dust could not contribute appreciably to the nitrogen found in the samples. This is to some extent further supported by the lack of nitrate in the samples. The samples were collected in early and mid-winter when the pollen contribution would be negligible. It seems that precipitation, at least in New Zealand, does in fact contain appreciable quantities of bound nitrogen which does not arise from contamination.

Origin of Organic Nitrogen in Snow

The problem immediately arises as to the origin of this material. When one considers the geographical position of New Zealand, situated as it is in a westerly air stream and surrounded by thousands of miles of ocean, it is difficult to avoid the conclusion that the source is the ocean itself. The ocean, however, contains only about 0.008 p.p.m. of albuminoid nitrogen. Further, if the snow is analysed in more detail, one sees that it is not merely diluted sea water but that its potassium/sodium ratio is an order of magnitude greater than that of sea water.

In order to explain these facts, it is necessary to postulate that the upper, very thin layer of the ocean has a different composition from that of the rest of the ocean; in particular, that it is enriched in potassium, ammonium, organic material and organic nitrogen, and probably various other materials. It is suggested that most debris (for example, from plankton) is either heavier or lighter than sea water and, if heavier, sinks to form sediments, and if lighter, rises to form this layer, which therefore contains micro-organisms and other plankton in a state of partial decomposition and would be expected to be rich in organic matter. It would also be expected to have an increased potassium/sodium ratio, since many marine organisms concentrate potassium. It is known[3] that when a bubble of gas passes through a liquid-gas interface, the act of the bubble bursting throws up a small droplet from the surface of the liquid into the gas phase. This must occur in the phenomenon known as 'white caps' (that is, when a wave breaks). The haze produced by these particles is quite noticeable on a fine day when a heavy surf is running. Thus, the composition of these droplets reflects that of the surface layer and not that of the bulk ocean.

It is reasonable to assume from the foam produced in rough ocean that some surface-active material is present on the surface of the ocean. During strong onshore winds, large quantities of foam accumulate on the shores of New Zealand which provides an opportunity to sample directly the surface layer of the ocean. A sample of ocean foam was collected on the west coast just north of Wellington. The foam was broken with a silicone anti-foaming agent and allowed to stand. It proved to be 25 per cent solid matter. On microscopic examination, this material was found to be particularly rich in bacteria and also had large quantities of diatoms and fragments of phyto- and zoo-plankton. The chemical analysis of this material is shown in Table 1. It is interesting to note the high nitrogen content and that the potassium/sodium ratio is higher than that in sea water.

The relationship between the surface layer of the ocean and snow water is most clearly seen when one plots the 'excess potassium concentration' against the 'albuminoid nitrogen concentration'. This is done in Fig. 1. The excess potassium concentration is obtained by subtracting from the potassium concentration 1/27 of the sodium concentration, that is, that amount of potassium which would be associated with the sodium in sea water. We see that the results from the ocean foam and the snow water samples lie on a straight line which can be extrapolated back to give the albuminoid nitrogen concentration in sea water. This is strong evidence in favour of their common origin, and supports the hypothesis that the

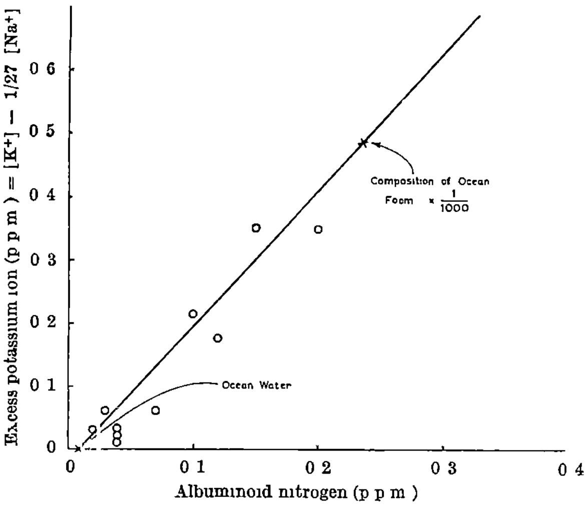

Fig 1

nitrogen in snow originates in the surface layer of the ocean

The above evidence suggests a new path in the nitrogen cycle, at least for New Zealand, and probably for other areas with rough oceans to their windward Elementary nitrogen dissolves in the sea and is fixed by marine micro-organisms These eventually rise to the surface and are caught in the surface layer, where some are partly decomposed by other micro-organisms into ammonia and other products The micro-organisms and their decomposition products are carried into the air by a bursting air bubble in a 'white cap' In the air the droplet would lose its moisture and a part of its ammonia, and as a small and light particle be carried far inland to settle out or to serve the very useful function of seeding rain clouds On reaching the ground this material would contribute to the soil, nitrogen and potassium and possibly other materials necessary for plant growth From the lack of NO_2' and NO_3' in the samples, this path in the nitrogen cycle might be considered more important than the conventional fixation of atmosphere nitrogen by atmospheric electrical discharges, at least for the areas covered by the sampling This then might represent a net transfer of bound nitrogen from the ocean to the land

Table 1

Description of sample	Nitrogen content of snow samples (ref 3)								
	NO_3' (p p m)	NO_2' (p p m)	NH_4^+ (p p m)	Organic (albuminoid) nitrogen (p p m)	Sum (p p m)	Na^+ (p p m)	K^+ (p p m)	Corrected $K^+ = K^+ - 1/27\ Na^+$ (p p m)	K^+/Na^+
(1) Snow collected April 26, 1958, 6,000 ft (tree line 4,000 ft) during snowstorm on Mt Ruapehu (100 miles from sea) Wind W S W	0	trace < 0 002	0 08	0 15	0 23	1 38	0 4	0 35	0 29
(2) Freshly fallen snow collected April 26, 1958, at 5,300 ft on Mt Ruapehu	0	trace < 0 002	0 03	0 2	0 23	1 35	0 4	0 35	0 296
(3) Snow collected May 3, 1958, at 6,000 ft (tree line 4,000 ft) on Mt Egmont (20 miles from sea)	0	0	0 03	0 1	0 13	0 68	0 24	0 215	0 354
(3*a*) Snow taken under (3)—previous snowfall ?	0	trace < 0 002	0 05	0 03	0 08	1 02	0 1	0 06	0 098
(4) Snow collected April 27, 1958, at 7,000 ft (tree line 3,000 ft) on Tasman Glacier (25 miles from sea)			0 1	0 12	0 22	0 20	0 18	0 175	0 90
(5) Rain collected in Wellington in southerly storm on April 26, 1958 Distance up wind to open sea 10 miles, altitude 10 ft	0	0 002	0 27	0 2	0 47				
(6) Snow collected July 20, 1958, at 5,750 ft (tree line 4,000 ft) during a snowfall on Mt Ruapehu) (100 miles from sea)	0	0	0 2	0 04	0 24	0 15	0 01	0 01	0 067
(7) Snow collected July 21, 1958, at 6,575 ft Same fall as in (6)	0	0	0 33	0 07	0 40	0 16	0 06	0 06	0 375
(8) Snow collected July 21, 1958, at 8,070 ft Same fall as in (6)	0	0	0 2	0 02	0 22	0 11	0 03	0 03	0 273
(9) Snow collected August 2, 1958, at 6,000 ft during snowstorm on Mt Ruapehu	0	0 001	0 02	0 09	0 11				
(10) Fresh snow collected August 22, 1958, at 5,000 ft at Temple Basin, Arthur's Pass (tree line 3,000 ft , 30 miles from sea)	0	0 002	0 01	0 04	0 05	0 04	0 02	0 02	0 50
(11) Fresh snow collected September 10, 1958, at 5,700 ft on Mt Ruapehu	0	0	0 01	0 04	0 05	0 65	0 05	0 03	0 077
(12) Ocean foam collected on rocky coast north of Wellington during strong on-shore westerly wind					235	12,000	930	485	0 078
(13) Typical ocean water		0	0 004	0 008		11,000	410	0	0 037

Application of Hypothesis to Other Problems

Origin of Ammonia in Air and Rain The presence of ammonia in air and rain has been known for many years Its origin, however, has been in doubt[4] The ocean seemed to be the most likely source except that calculations based on the equilibrium constant between air and water, together with the concentration of ammonia in the sea, rule out this possibility, even though in New Zealand's case there seems to be no other The hypothesis presented in this article would imply that the ammonia is coming, not from the bulk ocean, but from the surface layer and from the evaporation of the small droplets which are thrown up into the air by the bursting bubbles Variable quantities of ammonia will be lost by these droplets to the air, depending on their pH and composition Indeed, the results in Table 1 seem to show that the higher the albuminoid fraction the lower the ammonia retained in the droplet and vice versa This might be due to the buffering effect of the basic nitrogenous material

Potassium/sodium ratio in rain water It is a well-known fact that the potassium/sodium ratio in rain water is often larger by a factor of 10 than that in the sea—the obvious source This can be readily explained in terms of the above hypothesis, since the rain would derive its salts from the surface layer of the ocean, which in turn is rich in marine organisms, many of which are known to have much higher potassium/sodium ratios than the 1/27 of sea water

Charge discrepancy in rain water The total sums of all the charges carried by the anions and cations in rain water sometimes do not balance. This can be explained by the presence of organic compounds balancing the excess charge.

Ocean foam The origin of the foaming agent in the sea is not certain, but it is possible that it is produced by the bacteria themselves and serves to trap their food and also to aid in their aeration

Many of the sheep stations on the New Zealand coasts and islands carry more sheep than might from other considerations be expected, and without aerial top-dressing[5] This effect decreases with distance from the sea, and applies only to areas lying within 10 miles of the coast Could this be the result of wind-blown foam carrying plant nutrients to these coastal areas ?

Bacterial action of the sea There is a discrepancy between the supposed bacterial action in the sea and the very few bacteria found therein[6] Is it possible that a large fraction of these biological processes takes place on the surface layer of the ocean, and that these are not effectively sampled by the normal methods which sample the bulk ocean rather than the surface ?

Life in the inter-tidal zone The occurrence of large quantities of organic matter and nutrients in the surface layer of the sea might provide the food supply for the large amount of life that exists in and near the inter-tidal zone

I wish to thank Mr H J Wood of the Dominion Laboratory, Wellington, for the nitrogen analyses, and Mr A J Heine and Mr G Pallo, Department of Scientific and Industrial Research, for collecting samples

[1] Wilson, A T , *Nature*, 183, 318 (1959)

[2] "Standard Methods for the Examination of Water and Sewage" (American Public Health Association, 1790 Broadway, New York)

[3] Woodcock, A H , Kientzler, C F , Arons, A B , and Blanchard, D C , *Nature*, 172, 1144 (1953)

[4] Eriksson, E , *Tellus*, 3, 215 (1955)

[5] Aitken, R (private communication, Orongorongo Station, Wainui-o-mata, New Zealand)

[6] Harvey, H W , "The Chemistry and Fertility of Sea Water" (Cambridge University Press, 1955)

COMBINED EFFECTS OF CORTISONE AND INSULIN ON DEVELOPING CHICKEN EMBRYOS

By Dr PIETRO de FRANCISCIS* and Prof WALTER LANDAUER
University of Connecticut

THE injection of insulin into the yolk sac of chicken eggs after an incubation period of 4–8 days is responsible for the occurrence of a shortening of the long bones of the legs (micromelia) and of abnormalities of the beak , the mean body-weight of such embryos is somewhat reduced The severity of these symptoms varies with the amount of injected insulin[1] The principal effect of cortisone, injected during the same developmental stages, is a marked dwarfing of the embryos, but without the production of skeletal malformations[2] When both insulin and a potent adrenal cortex extract (but of unknown cortisone concentration) were injected after 5 days of incubation, it was found that the incidence of insulin-specific skeletal abnormalities was significantly greater than after the injection of insulin alone[3 4] In similar experiments, but done after 8 days of incubation and using cortisone in combination with insulin, Lunardo and de Bastiani did not find a potentiation of the insulin effect[5] It seemed of interest, therefore, to determine if differences of developmental stage are responsible for dissimilarities in the effects produced by simultaneous treatment with cortisone and insulin or if the discrepancies between our earlier observations and those of Lunardo and de Bastiani have other causes

For our present tests we used eggs of White Leghorn fowls Sterile solutions of cortisone (cortone acetate, Merck) and of insulin (Lilly) were injected into the yolk sac after 4 or 8 days incubation. The details of our experiments are presented in Tables 1 and 2 In recording skeletal abnormalities, all degrees of shortening of the legs were pooled , similarly, all types of beak defects were grouped together The incidence of other skeletal abnormalities was very small and was not separately recorded , these defects occurred with about equal frequency in all groups and, since there was no reason for believing that they owed their origin to our experimental procedures, they were added to the 'normal' groups

Untreated eggs served as controls of the various experimental groups For the test reported in Table 1 we had 37 fertile and untreated eggs , 33 of these

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* Fellow of the Italian National Research Council

Table 1. EXPERIMENTS IN WHICH CORTISONE, INSULIN, OR BOTH CORTISONE AND INSULIN WERE INJECTED INTO THE YOLK SAC OF WHITE LEGHORN EGGS AFTER 96 HR. OF INCUBATION AND AT THE DOSAGES GIVEN BELOW

	Cortisone			Insulin			Insulin and cortisone		
Experiment	1	2	3	1	2	3	1	2	3
Insulin units/egg	—	—	—	3.2	3.2	4	3.2	3.2	4
Cortisone, mgm./egg	1.25	1.25	1	—	—	—	1.25	1.25	1
Number treated	26	27	30	26	27	30	54	48	90
Survival to eighteenth day, per cent	57.7	81.5	76.6	84.6	63.0	73.0	37.1	47.8	35.5
Number survivors	16	22	23	22	17	22	20	23	32
Body-weight, gm.	14.26 ± 0.98	13.73 ± 0.86	13.90 ± 0.83	19.59 ± 0.81	15.15 ± 0.79	13.37 ± 0.73	12.70 ± 0.87	8.71 ± 0.50	10.14 ± 0.67
Normal, per cent	100	100	100	87.0	64.7	36.4	75.0	65.2	18.8
Short legs, per cent	0	0	0	13.0	35.3	54.5	25.0	34.8	59.4
Abnormal beak, per cent	0	0	0	13.0	11.8	27.3	5.0	4.4	25.0

In those groups in which both hormones were injected the ratio of cortisone to insulin amounted to 0.39 in experiments 1 and 2 and to 0.25 in experiment 3. All living embryos were weighed and examined after 18 days of incubation. Incidence of 'normal' embryos and of abnormalities of the legs or beak in percentage of survivors to eighteenth day. Standard errors of body-weight

Table 2. EXPERIMENTS IN WHICH CORTISONE, INSULIN, OR BOTH CORTISONE AND INSULIN WERE INJECTED INTO THE YOLK SAC OF WHITE LEGHORN EGGS AFTER EIGHT DAYS OF INCUBATION AND AT THE DOSAGES GIVEN BELOW

	Cortisone			Insulin			Insulin and cortisone		
Experiment	1	2	3	1	2	3	1	2	3
Insulin units/egg	—	—	—	3.2	3.2	4	3.2	3.2	4
Cortisone, mgm./egg	1.5	1.5	1	—	—	—	1.5	1.5	1
Number treated	40	10	55	40	20	55	70	40	80
Survival to eighteenth day, per cent	67.5	90.0	89.1	80.0	90.0	80.0	68.5	87.5	73.7
Number survivors	27	9	49	32	18	44	48	35	59
Body-weight, gm.	11.87 ± 0.52	13.92 ± 0.65	16.56 ± 0.45	18.20 ± 0.47	16.95 ± 0.50	17.75 ± 0.49	13.53 ± 0.42	13.24 ± 0.42	14.85 ± 0.56
Normal, per cent	100	100	100	50.0	27.8	34.1	81.3	71.4	49.2
Short legs, per cent	0	0	0	50.0	72.2	65.9	17.9	28.6	50.8
Abnormal beak, per cent	0	0	0	0	5.6	0	5.1	0	18.6

In those groups in which both hormones were injected the ratio of cortisone to insulin amounted to 0.47 in experiments 1 and 2, and to 0.25 in experiment 3. All living embryos were weighed and examined after 18 days of incubation. Incidence of 'normal' embryos and of abnormalities of the legs or beak in percentage of survivors to eighteenth day. Standard errors of body-weight.

(89.2 per cent) survived to 18 days and the embryos at that age had a mean body-weight of 20.95 ± 0.53 gm. As controls for the experiments of Table 2 we had 26 fertile and untreated eggs; 22 of the embryos (84.6 per cent) lived at 18 days and had a mean weight of 19.37 ± 0.56 gm. None of these 55 embryos showed skeletal malformations of the kind with which the present discussion is concerned.

Effects on survival. Among embryos treated at 4 days with both insulin and cortisone the mortality was consistently higher than it was in the groups treated with either hormone alone. In fact the toxicities of insulin and cortisone were nearly additive, and most of the group differences in mortality (or survival) are highly significant. At 8 days, on the other hand, survival after the combined treatment did not differ significantly from that occurring after injection of either insulin or cortisone. Comparing the experiments at 4 and 8 days, and taking into account such dissimilarities of dosage as existed, no consistent or significant changes appear to have occurred in the toxicity of either cortisone or insulin. Highly significant differences are found, however, between the combined treatments at the two developmental stages. In experiments 1 and 2, in which the ratio of cortisone to insulin was higher at 8 days than at 4 days (0.47 vs. 0.39), the differences amounted to 31.4 ± 8.65 and 39.7 ± 8.90 per cent respectively; in the two third groups, with identical ratios (0.25), the difference in survival was 38.2 ± 7.04 per cent.

Effects on body-weight. Following treatment after 4 days of incubation, the injection of both hormones led in all three groups to a greater retardation of growth than that produced by either insulin or cortisone. In groups 2 and 3, the mean body-weights, after combined treatment, fell significantly below those of the groups treated with either cortisone or insulin alone. At 8 days the combined treatment led to a significantly lower body-weight in comparison with the insulin-treated embryos; but the differences between the groups that had been injected with both hormones and those that had received only injections of cortisone were neither consistent nor statistically significant. A comparison of the treatments at the two development stages reveals some interesting differences. Against the lowest amount of cortisone which we used (1 mgm./egg) the 8-day embryos had become significantly more resistant than those treated at 4 days, their mean body-weight being 2.66 ± 0.94 gm. higher; the results of experiments 1 and 2 are not directly comparable because of dosage differences. The injection of 3.2 units of insulin at 4 and 8 days did not produce significant dissimilarities in body-weight, but after 4 units the 8-day embryos were less retarded (difference: 4.38 ± 0.88 gm.). The results for combined injection of insulin and cortisone in experiments 1 and 2, because of dosage differences, do not allow a comparison between 4 and 8 days, but the results of tests with 1 mgm. cortisone and 4 units insulin (experiments 3) demonstrate that growth of the embryos treated at 8 days was much less retarded than it was following injection at 4 days (difference: 4.71 ± 0.27 gm.).

Teratogenic effects. As one would expect, the incidence of malformations increased with dosage in the groups treated with insulin alone and in those treated with insulin and cortisone. This was true at both developmental stages. A comparison of the effects of insulin treatment with the results of the combined injection of insulin and cortisone shows no significant differences in the incidence of skeletal defects at the 4-day stage, except for a slight but consistent trend of the abnormalities to be more extreme in the groups treated with both hormones; in the groups tested at 8 days, on the other hand, the combined treatment was less teratogenic than injection of insulin alone. For the pooled data of experiments 1 and 2 (with identical ratios of cortisone

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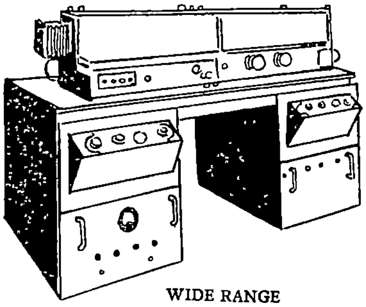

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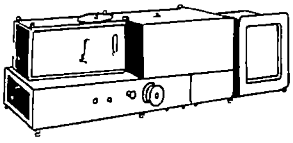

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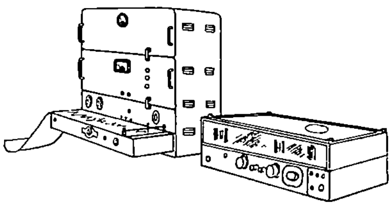

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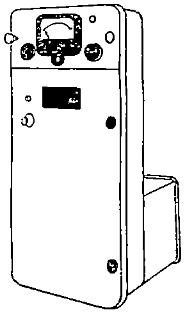

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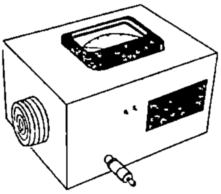

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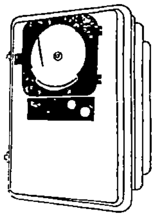

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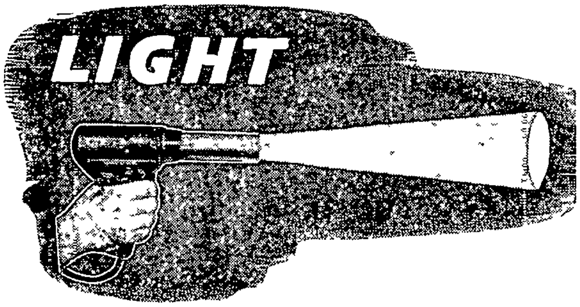

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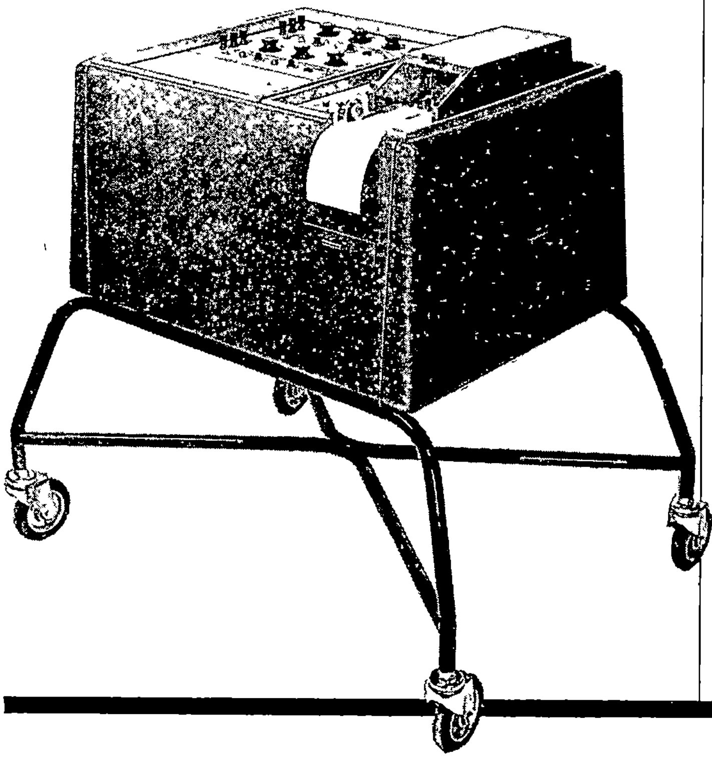

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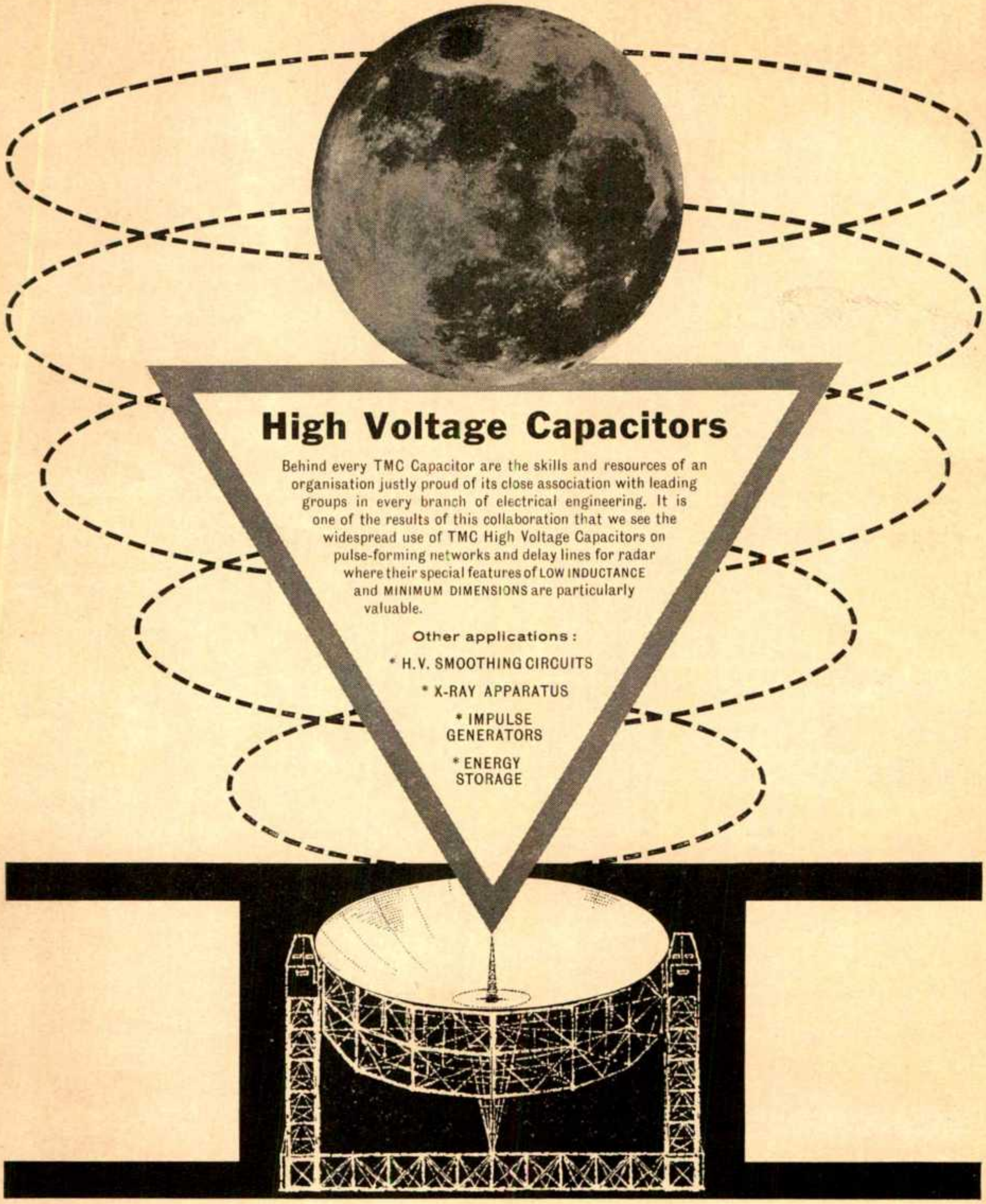

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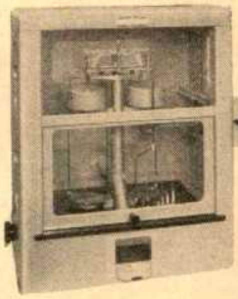

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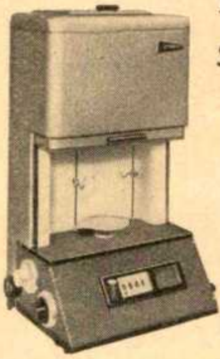

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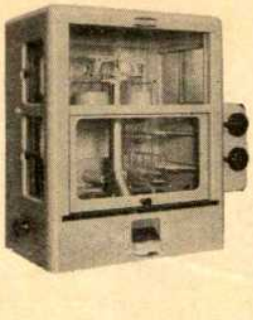

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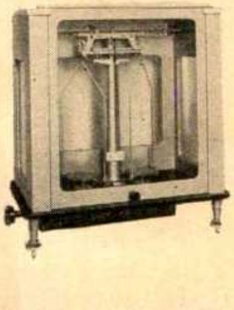

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to insulin) these differences were highly significant ($\chi^2 = 16.82$, $P < 0.001$), and the same is true for the combination of probabilities for experiments 1, 2 and 3 ($\chi^2 = 30.31$, d.f. $= 6$, $P < 0.001$).

Our results demonstrate clearly that between 4 and 8 days of incubation a change occurs in the reactions of the developing chicken embryo to combined treatment with insulin and cortisone. The older embryos survive better, show less retardation of growth and a lower incidence of skeletal malformations. These differences in response presumably are a reflexion of the homœostatic forces which the incipient functioning of the endocrine systems brings into play. Our observations, secondly, confirm the report by Lunardo and de Bastiani that cortisone does *not* potentiate the teratogenic action of insulin. Since our earlier experiments with an extract of adrenal cortex produced very striking potentiation, it must be concluded that this was due not to 17-hydroxy-11-dehydrocorticosterone (cortisone) but to one or more of the other corticosteroids contained in the extract. This we hope to verify in future experiments.

[1] Landauer, W., *J. Exp. Zool.*, **105**, 145 (1947).

[2] Karnofsky, D. A., Ridgway, L. P., and Patterson, P. A., *Endocrinol.*, **48**, 596 (1951).

[3] Landauer, W., *Endocrinol.*, **41**, 489 (1947).

[4] Zwilling, E. (unpublished observations).

[5] Lunardo, C., and de Bastiani, G., *La Clin. Ortoped.*, **8**, 120 (1956).

MATERNAL CONTROL OF OVARIOLE NUMBER IN THE PROGENY OF THE MIGRATORY LOCUST

By F. O. ALBRECHT
Laboratoire d'Evolution des Etres Organisés, Paris

M. VERDIER
Laboratoire de Biologie Animale, Paris

AND

R. E. BLACKITH
Imperial College Field Station, Sunninghill, Berks

AN integral part of the phase theory of locust transformations is the cumulative transmission of phase characters from one generation to another, so that fully *gregaria* or *solitaria* types can be obtained only when crowding or isolation of the locusts is maintained for several generations. The transmission of phase status to the progeny is held to occur through the accumulation of extra-chromosomal materials in the egg[1]. Early criticisms, understandably in view of the specific status given to the phases previously, held that they were genetically distinct but formed hybrids.

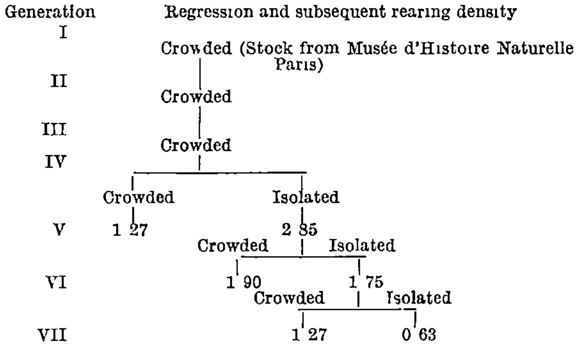
The weight of field and laboratory evidence has now accumulated to the point where the essentially non-genic nature of this inheritance is taken for granted, although the capacity of expressing it depends patently on the genotype concerned. This striking illustration of what Thoday[2] has called phenotypic flexibility has received scant notice save for some remarks of Kennedy[3,4].

Hunter-Jones[5] has shown that crowded female desert locusts, reproducing parthenogenetically, produce offspring which in colour and weight are typically *gregaria* whereas the same stock of females, when isolated, give *solitaria*-type larvæ. Our experiments show that telotykous parthenogenesis also occurs with the migratory locust, *Locusta migratoria migratorioides* R. and F. Moreover, the number of ovarioles in female offspring of isolated unfertilized females ranges from 95 to 105, whereas hatchlings from crowded mothers carry only 75–85 ovarioles. We may look to the female reproductive system for some of the clues to this problem.

There seem, in fact, to be two physiological processes at work; one of these operates through the vitellus of the egg, the reduction of which by ligaturing after blastokinesis produces larvæ which have the *solitaria* coloration (pale green) from crowded stocks of the migratory locust, the normal larvæ of which would be black and heavy[6]. Generally, weight and colour are closely associated[5], both with one another and with the subsequent rate of development and number of moults of some species of locust[7,8]. The number of ovarioles borne by these ligatured larvæ is, on the contrary, typical of *gregaria* populations. Thus the inheritance of this important phase character[9] seems to be independent of the amount of vitellus remaining in the egg. This distinction, however, may prove to be one of the timing of the processes of ovary formation and larval coloration; in *Melanoplus* and *Drosophila* at least, ovariole number seems to be determined prior to or during blastokinesis[10,11].

Table 1. MEAN REGRESSIONS OF OVARIOLE NUMBER ON HATCHLING WEIGHT OF THE MIGRATORY LOCUST, REPRESENTING THE INCREASE OF POTENTIAL REPRODUCTIVE CAPACITY FOR A SACRIFICE OF 1-MGM. WEIGHT AT BIRTH

(Standard errors of regression coefficients about 0.25 throughout)



There is in general an inverse relation between weight at hatching and the number of ovarioles in locust larvæ[9,12]. The interlocking of these two characters depends on the consistency with which the earlier generations have been kept crowded or isolated. To the extent that we may think of this relationship as a measure of the interchangeability of reproductive potential (number of ovarioles) and larval mobility (weight of occluded food reserves) the changes of its magnitude are of interest whatever the mechanism of inheritance Table 1 shows the mean regressions of ovariole number on hatchling weight for comparisons made among larvæ issuing from one and the same egg-pod Each pod contains up to 100 eggs derived from a single ovarial cycle in the female Comparisons across egg-pods or across the progeny from different females are swamped by extraneous sources of variation which themselves depend on the consistency of ancestral density Generation VI (crowded grand-parents, isolated parents) were 67 times as variable as generation VII, for which isolation was the parental and grandparental regime Yet even generation VII was 9 times as variable, as a whole, than were contrasts made within egg-pods as are those in Table 1 these varied in precision scarcely at all throughout the experiment

Crowding leads to a cumulative gain in weight at hatching for a given sacrifice of reproductive potential, and since this sacrifice has evidently not entirely been made good even three generations after crowding was ended we have the longest reach, of any yet recorded, of a density-dependent effect being transmitted to the descendants of the crowded generation Similar inheritance has, however, been demonstrated in the shorter run with other characters[6,7] In a general and less-precise way this inverse relation may be extended to fully *solitaria* and *gregaria* females, the progeny of the *gregaria* are fewer and heavier, and have fewer ovarioles compared with the progeny of *solitaria*, nevertheless, both phases produce about 1 gm of living material in each egg-pod

Setting Limits to Selective Action during the Egg Stage

Our series of 6,000 preparations of the dissected ovaries of several generations of the migratory locust affords an opportunity to set limits to the action of any selective forces operating during the development of the eggs, for the number of ovarioles in the laying female is the upper limit to the number of her progeny from which the issue of any one egg-pod can have been selected, always excluding the possibility of pre-ovogenetic selection In particular, the sequence of egg-pods laid by isolated females was studied either when the female was left with the male after copulation for the rest of her life, when the number of ovarioles in her progeny steadily diminished, or when the male was removed after 24 hr in the cage, to allow copulation to occur, when no such diminution was observed The influence of the male, once fertilization has been accomplished, is mildly to disturb the female and to induce a modest amount of those inhibitory effects normally associated with crowding The mean ovariole number of offspring from a female left with one male drops by one ovariole for each of the 15 or so reproductive cycles that the female undergoes More drastic crowding augments this progressive loss but also shortens the sequence of reproductive cycles so that the net effect is not greatly different

'Crowding' the females with a single male produces offspring of which the mean number of ovarioles eventually lies outside the range of the phenotypes initially produced by the same mating pair At most, less than half this cumulative shift can be attributed to selection, and in fact there is no evidence that any of it is so induced The absence of such a shift, in females from whom the male is removed within a few hours of copulation, excludes any influence of age alone on the mother

Regulation of Fertility and Fecundity in the Migratory Locust

Implicit in the phase theory of locust outbreaks is some autoregulation of fertility or fecundity according to the population density Our results provide some idea of the nature of such regulation in the migratory locust, other species seem to differ in important respects, and caution is needed in extending these findings to them

The influence of crowding operates both within and between generations The distinction between larval and adult crowding is vital for these comparisons, since changes of density rather than the level of the density seem to elicit the regulatory processes Crowding during the larval instars almost doubles the number of egg-pods laid by the ensuing adult females, whereas adult crowding inhibits the laying female either from fulfilling her potential delivery of egg-pods or from endowing her female offspring with their appropriate complement of ovarioles In this way larval and adult crowding act in opposite directions, and may substantially nullify one another during consistent crowding Yet when the larvæ are crowded and the adults isolated, as occurs with stragglers from gregarious groups, as many as 1,500 eggs may be laid by each female, when the reverse regime is imposed, only about a tenth of this number is to be expected

However clearly one may recognize that these ideas relate only to a few aspects of a much wider problem, the control of fecundity in the migratory locust may be regarded as a homœostatic mechanism tending to stabilize population density In every generation we have found a significant negative regression of ovariole number on hatchling weight, which we interpret as a latent ability to exchange larval food reserves for reproductive capacity When grouped locusts are dispersed, this adjustment is called into play and only fades away when several generations of isolation have failed to restore the population density through an increase in fecundity of the offspring The last word in these matters often lies with the climate, which can override the locusts' best endeavours at regulation[13]

Generally, it appears that the ability to produce offspring, the average fecundity of which is well outside the phenotypic range of the parents, lies at the heart of the capacity of migratory locusts to cope with rapidly changing environments An analysis of growth and of moulting polymorphism in the red and desert locusts led us to conclusions in the same vein[8] A full account of the experiments on which the present conclusions are based is being published[9]

[1] Uvarov, B P, *Bull Ent Res*, 12, 135 (1921)
[2] Thoday, J M, *Symp Quant Biol*, 20, 318 (1955)
[3] Kennedy, J S, *Biol Rev*, 31, 349 (1956)
[4] Kennedy, J S, *Proc Linn Soc Lond*, 168, 62 (1958)
[5] Hunter-Jones, P, Anti-locust Bull, Lond, No 29 (1958)
[6] Verdier, M, Proc 3me Cong Etude Insectes Sociaux (1957)
[7] Albrecht, F O, *J Agric Trop Bot Appl*, 2, 109 (1955)
[8] Albrecht, F O, and Blackith, R E, *Evolution*, 11, 166 (1957)
[9] Albrecht, F O, Verdier, M, and Blackith, R E, *Bull Biol Fr-Belge*, 82, 349 (1958)
[10] Nelsen, O E, *J Morph*, 55, 515 (1934)
[11] Robertson, F W, *J Genet*, 55, 410 (1957)
[12] Albrecht, F O, and Verdier, M, *C R Acad Sci Paris*, 243, 203 (1956)
[13] Albrecht, F O, *Locusta* (Nogent-sur-Marne), No 4, 1 (1956)

SUPPLEMENT No 2

NATURE
A WEEKLY JOURNAL OF SCIENCE

LECTURES AND COURSES

HUDDERSFIELD COLLEGE OF TECHNOLOGY

REGIONAL COLLEGE
DEPARTMENT OF CHEMISTRY, COLOUR CHEMISTRY AND DYEING
Head of Department
E Tittensor, B Sc , Ph D , F R I C
DIPLOMA IN TECHNOLOGY

The four year Sandwich Course in Chemical Technology leading to the Diploma in Technology, has a special bias towards the large scale manufacture of organic compounds, contains an appreciable study of Chemical Engineering, and is specially designed for students wishing to make a career in the chemical industry Entrants (either industry based or college based) should have either (a) G C E Advanced level in Chemistry and Physics, with Mathematics and two other subjects at Ordinary Level, or (b) a good Ordinary National Certificate in Chemistry or Applied Chemistry

The Royal Institute of Chemistry has approved the course for exemption purposes on the same basis as a University Degree, and students obtaining the Diploma in Technology with First or Second class honours may apply for exemption from the whole of the Grad Mem R I C examination

Further particulars and forms of application may be obtained from the Principal of the college

H GRAY,
Chief Education Officer

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, S W 3
DEPARTMENT OF CHEMISTRY
SESSION 1959-60
Head of Department J F J Dippy, D Sc , F R I C

Recognized Day and Evening Courses leading to the B Sc General degree (London, Internal), and the Graduateship and the Diploma (Food and Drugs) of the Royal Institute of Chemistry, commence on Monday, September 28, 1959 Various postgraduate courses are also available

Full particulars on application to the Secretary

WOOLWICH POLYTECHNIC

DEPARTMENT OF MATHEMATICS
M Sc COURSE

Applications are invited from suitably qualified candidates for a one-year full-time course leading to the M Sc degree in Mathematics

The Department offers courses in the subjects (a) Functions of Mathematical Physics (b) Elliptic Functions (c) Hydrodynamics (d) Electromagnetic Theory, (e) Elasticity and Plasticity, of which two must be studied

The Department of Scientific and Industrial Research has accepted this course as suitable for the tenure of its Advanced Course Studentships Applications should be made both for the course and the studentships to the Head of the Mathematics Department as soon as possible

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF CHEMISTRY
ANALYTICAL METHODS

A second series of postgraduate lectures on more recent analytical techniques will be held during the Autumn term on Tuesdays at 7 15 p m , commencing on October 20th, 1959 The topics will include mass spectrometry, non-aqueous solvents, activation analysis, complexometric titrations, EMR and microwave spectroscopy, ion exchange, X-ray fluorescence, and gas chromatography

A leaflet giving full details, and an application form may be obtained from the Head of the Chemistry Department, Chelsea College of Science and Technology, Manresa Road, London, S W 3

COVENTRY TECHNICAL COLLEGE

Principal A J Richmond, B Sc (Eng)(Lond), Ph D , M I Mech E
SANDWICH COURSE FOR GRADUATE MEMBERSHIP OF THE ROYAL INSTITUTE OF CHEMISTRY
SESSION, 1959-60

Applications are invited for a Sandwich Course of one year and two terms duration providing for twenty weeks of full-time study in each of two sessions in preparation for Part II Grad Mem R I C Candidates should already possess Part I, or expect to gain exemption this summer Industrial training is an integral part of this course for which both works-based and college-based students may be accepted In the latter case, the College is in a position to arrange industrial training locally for suitable applicants who can then apply for a Local Authority Award to cover the cost of maintenance for the College part of the course

Further particulars may be obtained from the Head of the Chemistry Department to whom applicants should write as soon as possible giving full details of their previous education

CITY OF LEICESTER EDUCATION COMMITTEE

LEICESTER COLLEGE OF TECHNOLOGY AND COMMERCE
Principal R E Wood, M Sc , F Inst P
Registrar A Martin, F C I S
SCHOOL OF CHEMISTRY
Head L P Priestley, B Sc , F R I C
POST-GRADUATE DIPLOMA IN RADIOCHEMISTRY
In charge of Course
R W C Broadbank, B Sc , Ph D , A R I C

THIS COURSE HAS BEEN ACCEPTED BY THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AS SUITABLE FOR THE TENURE OF ITS ADVANCED COURSE STUDENTSHIPS

A full-time post-graduate course in Radiochemistry will be held (Application for approval has been made to the Ministry of Education), from 1st October, 1959 to 31st December, 1960 This course will initially provide a general basic training in radio-isotope laboratory techniques, followed by more advanced training, with special emphasis on radiochemistry as a tool for research

The Post-Graduate Diploma (in Radiochemistry) of the College will be awarded to those students completing the course, who reach the required standard in a written examination and who submit a satisfactory dissertation and thesis on a topic allocated for study and research during the course

Qualifications for admission are a Degree in Chemistry or Grad Mem R I C or B Pharm (Hons), preferably with Chemistry to Part II Number of places available is limited so that individual attention can be given to each student Early application is desirable

Further particulars may be obtained from the Head of the School of Chemistry, Leicester College of Technology and Commerce, Leicester

UNIVERSITY OF BIRMINGHAM

FACULTY OF COMMERCE AND SOCIAL SCIENCE
NOTICE TO GRADUATES AND THOSE ABOUT TO GRADUATE IN SCIENCE

The Faculty offers a one year course for graduates wishing to prepare for a career in management, leading to the Graduates' Commerce Diploma

Applications for admission to the course starting in October, 1959, and requests for further information, should be made as soon as possible to the Registrar, University of Birmingham, Edgbaston, Birmingham, 15

The Department of Scientific and Industrial Research has accepted this course as suitable, in the case of candidates with honours degrees in Science, for the tenure of its Advanced Course Studentships

NETWORK FORMATION IN VULCANIZATION

A five-day course of lectures and practical work at post-graduate level on the investigation of cross-linking processes and the structure of cross-linked rubbers

September 21–25, 1959, inclusive

For details apply to National College of Rubber Technology, Holloway Road, London, N 7 Tel NORth 4231

BATTERSEA COLLEGE OF TECHNOLOGY

BATTERSEA COLLEGE OF TECHNOLOGY, London, S W 11 Physics Department The next series of lectures on MICROWAVE PHYSICS will begin on Monday, 5th October, 1959, at 6 30 p m The Course will deal with microwave theory, techniques and applications and is suitable for graduates in mathematics, physics and electrical engineering Suitably qualified students may proceed, as part-time students, to the Internal M Sc degree of the University of London or the postgraduate Diploma of the College Further details and enrolment forms may be obtained from the Secretary (Microwave Courses)

OFFICIAL APPOINTMENTS

UNIVERSITY OF SYDNEY

LECTURESHIP IN ORGANIC CHEMISTRY
(MICROANALYTICAL TECHNIQUES)

Applications are invited for the above position The Lecturer will be responsible for the routine microanalytical (organic) and spectroscopic (ultra-violet and infra-red) service, the training and supervision of technical assistants, instruction in microanalysis to senior students, and the development of improved methods of microanalysis The salary for a Lecturer is within the range £A1,500 by £A90 to £A2,100 per annum, plus cost of living adjustment, and will be subject to deductions under the State Superannuation Act The commencing salary will be fixed according to the qualifications and experience of the successful applicant Under the Staff Members' Housing Scheme in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 Applications close in Australia and London on September 5th, 1959

UNIVERSITY OF BRITISH COLUMBIA

DEPARTMENT OF PHYSICS

The University has a vacancy for an experimental solid state physicist to head a small group working on the optical properties of semi-conductors and photo-conductors and other effects involving infra-red radiation The appointment will be made at the Assistant Associate or Full Professor rank at a salary varying from $7,500 to $12,000 depending upon qualifications There will also be financial assistance for travelling to Canada The undersigned will be in Great Britain from September 1st to 5th to interview anyone interested Address c/o B C House, London, S W 1 Write for further particulars to

G M SHRUM,
Head, Department of Physics

UNIVERSITY OF LONDON

READERSHIP IN INORGANIC CHEMISTRY AT BIRKBECK COLLEGE

The Senate invite applications for the Readership in Inorganic Chemistry tenable at Birkbeck College (salary £1,475 to £1,775 to £2,150 a year plus £80 London Allowance)

Applications (10 copies) must be received not later than 15th September, 1959, by the Academic Registrar, University of London, Senate House, W C 1, from whom further particulars may be obtained

ROYAL NAVAL SCIENTIFIC SERVICE

Vacancies for Senior Scientific Officers and Scientific Officers in following localities

London Area Mechanical Engineer with sound knowledge of basic principles of thermo and fluid dynamics to carry out research programme in a particular field of applied hydrodynamics Experience in modern methods of design and research on axial flow compressors, turbines or pumps an advantage Mechanical Engineer for work on propulsion problems Applied Mathematician for research of basic nature on stability of underwater vehicles knowledge of theoretical hydrodynamics and theory of control systems an advantage Applied Mathematician or Theoretical Physicists for acoustic analysis Electronic Physicists for data handling and analysis problems Physicist interested in operator performance Classical Physicists

Baldock Physicists or Applied Mathematicians for research in Metal or Quantum Physics

Portsmouth Electronic Engineers for research on analogue computers and transistor circuits Electrical Engineers for research on small rotating electrical machinery Physicists—for optical systems and instrumentation Electro-mechanical engineers—for work on servo-mechanisms

Portland Physicists or Applied Mathematicians for research on underwater acoustics Electronic Physicists, Electronic Engineers—for design work Physical Chemists

Poole Chemical Engineers Chemists for work on rubber technology

Rosyth Physicists—(Electronic)

Candidates must normally be natural born British subjects of natural born British parents, with first- or second-class honours degrees Senior Scientific Officers must have had three years' postgraduate experience and be not less than 26 years of age Salaries (men) Senior Scientific Officer, £1 233 to £1 460 , Scientific Officer, £655 to £1,150 (London), somewhat lower in provinces Appointments unestablished (with F S S U benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts —Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S W 1 (quote A 220/9A)

BOROUGH POLYTECHNIC
BOROUGH ROAD, LONDON, S E 1

Principal James E Garside, M Sc Tech , Ph D , F R I C , F I M , F Inst F

The governors invite applications for the following new appointments

DEPARTMENT OF CHEMISTRY AND FOOD TECHNOLOGY

Head of Department
Francis Aylward, Ph D , D Sc , F R I C

Lecturer in Physical Chemistry—Candidates should have good acedamic qualifications, teaching experience and/or research experience Excellent research facilities available

Lecturer in Chemical Engineering—Candidates should possess good academic qualifications in chemical engineering, chemical technology, or physical chemistry, and preferably should have had industrial and/or teaching experience

The Lecturer appointed will be expected to—
(a) Take charge of the development of Chemical Engineering Courses
(b) Assist with Courses leading to the Diploma in Technology

Good research facilities available

Salary scale £1,200 by £30 to £1,350 per annum Successful candidates may be appointed at a point on the scale above the minimum if they have had previous experience in the grade for which they have applied or in some capacity which can be regarded as equivalent

In addition, London allowance of £36 or £48 is payable and the gross salary is augmented by 5 per cent special addition

Further particulars and Form of Application, which should be returned as soon as possible, obtainable from the undersigned

FREDK J PACKER
Clerk to the Governing Body

McGILL UNIVERSITY
DIRECTOR FOR THE COMPUTATION CENTRE

The centre is equipped with an I B M 650 Preference will be given to applicants with a wide scientific background Salary $11,000 Personal details should be sent to the Vice Principal, McGill University, Montreal, Quebec

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EAST AFRICA HIGH COMMISSION
METEOROLOGIST, EAST AFRICAN METEOROLOGICAL DEPARTMENT

Qualifications Honours degree in mathematics and/or physics Preference will be given to candidates with a post-graduate qualification and/or experience in meteorology, but this is not essential A successful applicant with no previous forecasting experience will normally be required to pass a training course

Age 21 to 35 but experienced candidates up to 45 would be considered

Duties Mainly chart analysis and weather forecasting but the officer may be required to undertake research

Terms of Appointment On probation to the permanent and pensionable establishment, or on contract for one tour (30–36 months) in the first instance with gratuity on satisfactory completion of service Salary in the scale £939–£1,863 per annum Outfit allowance Free passages Quarters provided at rental if available House or hotel allowance if quarters not provided Generous leave Medical attention available Taxation at local rates

Apply to Director of Recruitment, Colonial Office, London, S W 1 State full name, age, qualifications and experience Quote BCD/57/88/01/C1

TEHERAN UNIVERSITY
TECHNICAL FACULTY

Applications are invited for lectureships in WORKSHOP TECHNOLOGY, CHEMICAL ENGINEERING, ELECTRICAL ENGINEERING, MECHANICAL ENGINEERING AND GEOLOGY

Candidates must be British subjects with British University or equivalent qualifications and laboratory experience

Salary free of tax £2,750 a year plus free accommodation Contract for one year, renewable Return fares paid, also for family U K superannuation may be maintained and secondment from present employment might be arranged

Write, quoting N7(59) and enclosing stamped, addressed foolscap envelope to Director, Recruitment Department, British Council, 65 Davies Street, London, W 1 , for further particulars and application form, to be returned, completed, within two weeks of receipt

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UNIVERSITY OF NATAL
SOUTH AFRICA
DEPARTMENT OF BOTANY

Applications are invited from suitably qualified persons for appointment to the post of Lecturer in Botany, Pietermaritzburg An interest in Algae and Fungi is desirable

The salary scale attached to the post is £1,050 by £60 to £1,530 per annum The commencing notch on the above salary scale will be dependent on the qualifications and/or experience of the successful candidate

Application forms and further particulars of the post, including commencing dates, etc , are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W C 1

Applications close in South Africa and London on 31st August, 1959

NORTHERN POLYTECHNIC, HOLLOWAY, LONDON, N 7

The Governing Body invite applications for the post of Senior Lecturer in Inorganic Chemistry to commence in January, 1960 Experience in teaching and research essential Industrial experience would be an advantage The candidate appointed will be expected to initiate and direct research in his special subject Salary scale Men—£1,417 10s by £52 10s to £1,627 10s , Women—£1,336 10s by equal pay increments to £1,627 10s , together with allowances in accordance with the Burnham Award

Form of application and further particulars will be sent on request to the Clerk to the Governors

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UNIVERSITY OF BIRMINGHAM
DEPARTMENT OF CHEMISTRY

Applications are invited for a National Coal Board Postdoctoral Fellowship in Physical Chemistry The research work to be undertaken is connected with the study of solids by a number of techniques such as mass spectroscopy The salary will be £700 to £800 per annum according to age and experience

Applications (two copies) should be sent as soon as possible to the Deputy Registrar, The University, Edgbaston, Birmingham, 15

KING'S COLLEGE HOSPITAL
DENMARK HILL, S E 5

Applications are invited for an appointment as Senior Assistant Physicist The successful candidate will be expected to take responsibility in radiation physics and isotope work, and hospital experience is desirable He will have an opportunity of partaking in other branches of medical physics work including some research Salary according to Whitley Council scales for the Senior Grade £1,190 to £1,600, including London Weighting

Applications, together with the names of two referees, should be sent to the House Governor, King's College Hospital, Denmark Hill, London, S E 5

S W BARNES,
House Governor

GOVERNMENT OF TANGANYIKA
GEOLOGIST

Qualifications First or good Second-class honours degree in Mining Geology Post-graduate experience desirable Candidates with a First or good Second-class honours degree in geology and post-graduate experience in mining geology will be considered

Age Preferably under 35

Duties Regional mineral survey, detailed examination of producing mines and mineral prospects

Terms of appointment On probation to the permanent and pensionable establishment, or on contract for one tour (30–36 months) in the first instance with gratuity on satisfactory completion of the engagement Emoluments in the scale £981–£1,863 per annum Outfit allowance Education allowances for children Subsistence and transport allowances when travelling on duty Free passages Quarters provided if available at rental Generous leave Taxation at local rates Free medical attention

Apply to Director of Recruitment, Colonial Office, London, S W 1 State full name, age qualifications and experience Quote BCD 105/8/03/C1

WELSH PLANT BREEDING STATION
UNIVERSITY COLLEGE OF WALES
ABERYSTWYTH

Applications are invited for an officer with special interest in abstracting and translating to take charge of the Library of the Welsh Plant Breeding Station For further particulars apply to the Secretary, Welsh Plant Breeding Station, Plas Gogerddan, Near Aberystwyth

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BOTANY SCHOOL, OXFORD

Cytologist wanted to carry out experimental research with chromosomes under a D S I R grant tenable for three years under the present grant, beginning at any convenient time Candidates should hold a Doctor's degree and the salary will be in the range of £800–£1,100 plus F S S U Applications should be sent to the Sherardian Professor

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AUSTRALIAN NATIONAL UNIVERSITY
CANBERRA
RESEARCH SCHOOL OF PACIFIC STUDIES
READERSHIP OR SENIOR FELLOWSHIP IN BIOGEOGRAPHY

Applications are invited for appointment to a Readership or Senior Fellowship in the Department of Geography The qualifications desired are essentially in plant ecology, and tropical experience would be an advantage The status of the appointment made will be in accordance with qualifications and experience

The salary for Readers is within the range £A2,763–£A3,213 A Reader is appointed to the permanent staff, retiring age is sixty-five with the option of retiring after the age of sixty Senior Fellows are appointed at a salary in a range fixed within the limits £A2,553–£A3,063 and appointment is made for an initial period of five years, thereafter it may be made permanent

The person appointed will be entitled to one year's study leave on full pay plus a contribution of up to £A1,342 (if a Reader) or £A1,226 (if a Senior Fellow) towards travel and other expenses, in every six years

Superannuation on the F S S U pattern is provided and reasonable removal expenses are paid

Further details are available from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W C 1

Applications close in Australia and London on 15th October, 1959

STUDLEY COLLEGE, WARWICKSHIRE

AGRICULTURAL AND HORTICULTURAL COLLEGE FOR WOMEN

Principal Miss E E Hess, N D H

Applications are invited for the post of Assistant Lecturer in Agriculture to Diploma standard, from single or married men and women, with a degree in agriculture and/or N D A Some experience in practical farming and teaching

Salary will be on one or other of the following scales plus 5 per cent Farm Institute Scale Grade II (Men) £550 to £975 or Further Education Scale Assistant Grade B (Men) £650 to £1,025

Applications giving age, qualifications, experience, etc , and two referees to the Principal as soon as possible

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RADIOLOGICAL PROTECTION SERVICE (Medical Research Council and Ministry of Health), Clifton Avenue, Belmont, Sutton, Surrey, requires a Scientist with First or Second class Honours degree, to join a team of physicists and engaged chemists on problems concerned with the hazards to human beings from internally deposited radioactive materials The work will be mainly concerned with the evaluation of maximum permissible amounts of various isotopes in human beings and the measurement of body radioactivity by excretion methods Preference will be given to persons having an interest and training in both physics and biology

Salary according to age and qualifications at a point on the scales £750 by £50 to £850 or £900 by £100 to £1,100 per annum, plus London Weighting and child allowances

Applications with the name and address of two referees, to the Director, Mr W Binks, at the above address

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NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

(UNIVERSITY OF READING)

Appointment for approximately 5 years for research scientist to work on project administered under U S A Counterpart Funds Project includes application of new techniques in differentiation and recognition of strains of micro-organisms important in dairy products with aim of obtaining data useful in scientific control of manufacturing procedures Candidates should possess first or good second class honours in chemistry or biochemistry Some experience or training in bacteriology an advantage Starting salary, according to experience in the range £650–£1,120 p a Superannuation under F S S U Applications naming two referees and stating full particulars to the Secretary, N I R D Shinfield, Reading, Berks *Quoting ref* 59/8

CIVIL ENGINEERS FOR DEPARTMENT OF MAIN ROADS, NEW SOUTH WALES, AUSTRALIA

Applications are invited from graduates (or undergraduates in their final year) in Civil Engineering of a recognised British or Irish University for appointment to the staff of the Department of Main Roads, New South Wales, the State Road Authority for construction of roads and bridges

On appointment, applicants may be engaged at the Department's Head Office, Sydney, on the design of reinforced concrete and steel bridges, or on main road construction and maintenance either in the Metropolitan Area or the country

Commencing salary according to qualifications and experience will be within the range £A1,185 to £A1,410 per annum, with annual progression, subject to technical competence to £A2,095 per annum Appointees will be eligible to contribute to the State Superannuation Fund after six months

Appointee's full fare from England to Australia will be met by the Department, subject to a three years' service guarantee bond being completed Appointment will be subject to passing a medical examination and preference will be given to applicants not more than 30 years of age

Applications should be made on forms obtainable from the Agent General for New South Wales, 56 Strand, London, W C 2

UNIVERSITY OF GLASGOW

Research Assistant required to work on the effects of low temperature on mice Candidates should have a good degree in Zoology or Physiology Starting date as soon as possible Appointment in the first instance to 30th September, 1960 Salary not more than £650 per annum Applications, giving the names of two referees, should be sent at once to Dr S A Barnett, Zoology Department, The University, Glasgow, W 2

UNIVERSITY OF EDINBURGH

DEPARTMENT OF ENGINEERING

Applications are invited for the post of Assistant in the Department of Engineering Salary Scale £700 by £50 to £850 per annum, together with superannuation benefit and family allowance where applicable Candidates are normally expected to possess an honours degree in Mechanical or Civil Engineering The successful candidate will be encouraged to research with a view to obtaining a higher degree

The successful Candidate will be expected to take up duty on 1st October, 1959

Further information may be obtained from the undersigned, with whom applications, giving the names of two referees, should be lodged as soon as possible

CHARLES H STEWART,
Secretary to the University

COMMONWEALTH AGRICULTURAL BUREAUX

Applications are invited for the post of—

DIRECTOR, COMMONWEALTH BUREAU OF ANIMAL NUTRITION, ROWETT RESEARCH INSTITUTE, BUCKSBURN, ABERDEEN, SCOTLAND

The work of the Bureau is to collect, collate and make available to research workers information on the nutrition of man and animals and its implications for agriculture and human welfare Salary scale £2,200–£2,600 Provision for superannuation

Applications should be submitted by 31st October, 1959, to the Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks , from whom full particulars, including regulations for passages to overseas candidates on first appointment, can be obtained Government employees should apply through their governments

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UNIVERSITY OF NEW ENGLAND AUSTRALIA

TWO LECTURESHIPS IN GEOGRAPHY

Applications are invited for two positions of Lecturers in Geography These are new appointments to meet demands of increases in numbers of students Duties will include work with both internal and external students, but a substantial part of the work will be with external students by correspondence and at residential schools

Commencing salary will be determined according to qualifications and experience within the range £A1,500 by £A90 to £A2,100 plus cost of living allowance Provision is made for superannuation, travel and removal expenses, assistance in buying or building a house

Further information may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1

Applications close, in Australia and London, on 15th September, 1959

FISHERIES RESEARCH BOARD OF CANADA

A shellfish biologist is required for oyster research in eastern Canada probably with headquarters at Ellerslie, Prince Edward Island To be considered, an applicant must have a Bachelor s degree, or better, with biological training and ability to organize work and supervise subordinates The position will be classified Assistant Scientist ($4,600 to $5,800) or Associate Scientist ($6,000 to $7,500) according to the qualifications and experience of the successful applicant The Fisheries Research Board of Canada is an agency of the Government of Canada and service with it carries all the privileges (leave, superannuation, death benefit) of Public Service

Applications should be accompanied by statements of personal history and training and recommendations from former employers and professors, and addressed to the Director, Fisheries Research Board of Canada, Biological Station, St Andrews N B , Canada

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UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE

Department of Physics

A TECHNICIAN

required in the Department of Physics Experience with lecture demonstrations an advantage but not essential Commencing salary at an appropriate point on the Technicians' Scale (£440–£590) depending on age, qualifications and experience

Applications, giving full details of qualifications and experience should be addressed to the Professor of Physics, King's College, Newcastle upon Tyne, 1

UNIVERSITY OF DUBLIN

TRINITY COLLEGE

Applications are invited for the following posts in the School of Veterinary Medicine, duties to be taken up on January 1st 1960

Senior Lecturer in Bacteriology and Pathology
Senior Lecturer in Surgery
Lecturer in Biochemistry
Lecturer in Pharmacology
Lecturer in Bacteriology and Pathology
Lecturer in Animal Husbandry
Lecturer in Obstetrics

For the Lectureship in Biochemistry a Veterinary qualification is desirable, for all other posts a Veterinary qualification is essential

Salary scales Senior Lecturers £1,370–£1,775 (with increments of £135 at 10, 15 and 20 years), Lecturers £1,045 by £47 10s to £1,377 10s by £23 15s to £1,520, with membership of a non-contributory Superannuation and Life Assurance Scheme

Applications (three copies), stating experience and the names and addresses of three referees, should reach the Registrar, Trinity College, Dublin, from whom further particulars may be obtained, not later than September 30th, 1959

UNIVERSITY OF EDINBURGH

DEPARTMENT OF CHEMISTRY

Applications are invited for the post of Assistant in the Department of Chemistry Salary Scale £700 by £50 to £850 per annum, with superannuation benefit and family allowance where applicable Tenure is normally for three years The successful candidate will be expected to take up duty on 1st October, 1959

Further particulars may be obtained from the undersigned, with whom applications, giving the names of two referees, should be lodged as soon as possible

CHARLES H STEWART,
Secretary to the University

CRUMPSALL HOSPITAL, MANCHESTER, 8

Applications are invited for the post of —

RESEARCH BIOCHEMIST

in the Department of Pathology, Crumpsall Hospital

Applicants should hold an honours degree in Chemistry or Biochemistry, or be Associates of the Royal Institute of Chemistry Previous hospital experience not essential

The appointment will be in the basic grade of the N H S scales for Biochemists and will be for a period of three years

Applications, together with the names and addresses of two referees should be sent to the Hospital Administrator, Crumpsall Hospital, Manchester, 8

LONDON COUNTY COUNCIL

NORWOOD TECHNICAL COLLEGE

CHEMISTRY AND BIOLOGY DEPARTMENT

Research Assistant (Plankton), full time, required September, 1959, for two years (extension to three possible), to join small team (in association with N Z Institute of Oceanography) working on Plankton from waters south of New Zealand Work suitable for London University external M Sc or Ph D Applicants should be Zoology graduates (or taking Finals this year) with real interest in Plankton

Allowance £300 per annum (subject to review) plus about £150 per annum for about six hours teaching a week

Application forms from Principal at College, Knight's Hill, London, S E 27, to be returned within 14 days (1406)

DERBY AND DISTRICT COLLEGE OF TECHNOLOGY

Principal T Heap, Ph D , M Sc , F R I C , A M I I A

Applications are invited from Honours Graduates in Chemistry for posts as Research Assistants Posts are tenable for two years in the first instance

The persons appointed will carry out research work for higher degrees on one of the following

1 The relationship between sorption affinity of alumina for a series of organic solutes in non polar solvents and certain physical properties of the sorptives
2 A problem in nitrogen heterocyclic chemistry

Salary scale £550 by £50 to £650

Further particulars and application forms can be obtained from the Principal, Derby and District College of Technology, to whom completed applications should be returned as soon as possible

C MIDDLETON
Secretary to the Joint Education Committee

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF INDUSTRIAL METALLURGY

Applications are invited for a Lectureship in the Department of Industrial Metallurgy to lecture to final year and postgraduate students Good facilities are provided for research Candidates should have a good degree in Metallurgy or Chemistry and industrial or research experience, ability in thermodynamics and an interest in the application of science in the field of melting and solidification would be an advantage Salary within range £900 to £1 650 with F S S U and family allowance

Applications (three copies), with the names of three referees, should be sent to the Deputy Registrar, The University, Birmingham, 15, from whom further particulars may be obtained

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THE HOSPITAL FOR SICK CHILDREN

GREAT ORMOND STREET, LONDON, W C 1

Applications are invited for the appointment of Research Biochemist (Ph D standard) to work primarily on steroid chemistry in children The salary offered is within the range £1,190 to £1,600 per annum according to qualifications and experience Applications should be sent to Dr B Clayton, Department of Chemical Pathology from whom further particulars may be obtained

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UNIVERSITY OF LONDON KING'S COLLEGE

The College will require on October 1st, 1959, a Lecturer in Zoology Applicants should have experience in teaching the zoology of the invertebrates to Honours standard A special interest in parasitology, genetics or cell physiology would be an advantage, but is in no way essential

Salary scale £900 by £50 per annum to £1,350, then, after review, by £75 per annum to £1,650 Starting point according to qualifications and experience A London allowance of £60, family allowances and F S S U benefits will also be payable

Full conditions of appointment and application forms may be obtained from the Registrar, King's College London, Strand, W C 2, completed forms must reach him within a fortnight from appearance of this advertisement

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THE UNITED BIRMINGHAM HOSPITALS

THE GENERAL HOSPITAL BIRMINGHAM, 4

Technician, B Sc, or equivalent qualification Haematology Department, salary £535 to £635 per annum, and conditions of service as agreed by the Whitley Council Applications stating age and education and giving names of two referees, should be addressed to the House Governor

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UNIVERSITY OF EDINBURGH

DEPARTMENT OF ANIMAL GENETICS

Biochemist, or other suitably qualified person, required to collaborate with Dr G H Beale in genetical and biochemical work with *Paramecium* antigens The work is concerned with gene controlled variations in protein specificity Salary in accordance with qualifications

Further particulars may be obtained from Dr Beale, Institute of Animal Genetics, University of Edinburgh, The King's Buildings, West Mains Road, Edinburgh, 9

INSTITUTE OF ANIMAL PHYSIOLOGY

BABRAHAM, CAMBRIDGE

Assistant Experimental Officer with experience of Isotope counting equipment required to undertake maintenance, development and some routine duties Minimum qualifications G C E in five subjects including two (Science or Maths) at Advanced level, or equivalent Salary according to age in scale, £427 at 19, to £855 Contributory superannuation scheme Applications with the names of two referees to the Secretary within two weeks

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BIOCHEMIST required for research into brain metabolism, especially into the effects of stress on molecular and enzymic dynamics The work will be co-ordinated with that of a team on the cybernetic aspects of stress Initiative and adaptability are required rather than any highly specialised technique

Applicant should have a good Honours degree Facilities will be given for a Ph D thesis The appointment will be for three years in the first instance Salary in accordance with qualifications

Applications to the Director, Burden Neurological Institute, Stapleton, Bristol

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PLANT BREEDER (PYRETHRUM), KENYA

In addition to main duties in plant breeding, he will be required to take control of pyrethrum research and be responsible for agronomic trials with pyrethrum

Candidates must have a degree in Agriculture or Horticulture or an Honours degree in Botany with post-graduate training or experience in plant breeding Training in plant breeding can be arranged for a candidate without post-graduate experience

Appointment on probation for permanent establishment with pensionable emoluments in scale £981–£1,863 per annum Free passages on appointment and leave for officer, wife and children up to three adult passages in all Furnished accommodation, if available, at moderate rental

Apply giving brief particulars, to Director of Recruitment, Colonial Office, London, S W 1, quoting BCD63/7/014

DAIRY RESEARCH INSTITUTE (N Z)

BIOCHEMIST

Applications are invited for a position as Biochemist in the Bacteriological Department of the Dairy Research Institute (N Z) Palmerston North, New Zealand Commencing salary will be within the ranges £720 to £1,000 or £1,025 to £1,275, depending on experience, qualifications and age The appointee is required for research into cheese-ripening problems, and it would be an advantage to have some experience in bacteriological technique He will probably be required to work for a period of one or two years at the National Institute for Research in Dairying, at Shinfield, Reading, before proceeding to New Zealand

Further particulars may be obtained from the Secretary (Ref 59/11), National Institute for Research in Dairying, Shinfield, Reading

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LABORATORY STEWARD required to administer stores (including chemicals and glassware) and to service teaching laboratories, some scientific knowledge (particularly in chemistry) desirable and experience in glass-blowing an advantage Salary on scale £440–£590 Applications giving age, qualifications and the names of two referees to be addressed to Professor R D Preston, Department of Botany, The University, Leeds, 2

BIRKBECK COLLEGE

(UNIVERSITY OF LONDON)

Applications are invited from physical chemists or biochemists for a research fellowship for work on virus substructure in conjunction with a team studying the structure of viruses by physical methods Starting salary up to £1,250 per annum according to qualifications and experience Alternatively, graduates wishing to read for a higher degree might be considered for appointment to a Research Assistantship with a starting salary of up to £800 per annum

Candidates free to assume appointment on, or at any time before, October 1, 1959, should apply as soon as possible for further information to the Secretary, Birkbeck College, Malet Street, London, W C 1

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

(UNIVERSITY OF READING)

Honours Graduate in Bacteriology, or graduate with subsequent experience in bacteriology, to assist in work on bovine mastitis, mainly using one-egg twins Opportunities to study for higher degree Appointment to either Scientific Officer Class, commencing salary range £615 to £1,166, or Experimental Officer Class, £492 to £954, according to age, qualifications, and experience, F S S U

Applications, naming two referees, to Secretary, N I R D, Shinfield, Reading Quote ref 59/12

THE ROYAL SOCIETY

FOULERTON GIFT RESEARCH FELLOWSHIP

The Council of the Royal Society invites applications from candidates of British nationality for a FOULERTON GIFT RESEARCH FELLOWSHIP for original research in medicine The stipend will be in the range from £850 to £1,050 and the appointment is for two years in the first instance from 1st January, 1960 Application forms may be obtained with further particulars from the Assistant Secretary, The Royal Society, Burlington House, London, W 1, to whom they should be returned not later than 1st October, 1959

CITY AND COUNTY OF BRISTOL

THE COLLEGE OF TECHNOLOGY

(Designated as a College of Advanced Technology as from September, 1960)

The Governors invite applications for the following posts to commence on 1st September, 1959 or as soon as possible thereafter

LECTURER IN MATHEMATICS

Applicants should possess an honours degree in Mathematics or Statistics and should have teaching and research or industrial experience involving the application of mathematics to scientific or engineering problems Preference given to candidate with experience in statistical work

ASSISTANT GRADE B IN MATHEMATICS, for work up to and including Ordinary National Certificate Applicants should possess a degree in Mathematics and should have teaching and research or industrial experience involving the application of mathematics to scientific or engineering problems

Salary Burnham Scales —

Lecturer Men, £1,260 by £31 10s to £1,417 10s, Women, £1,008 by £25 4s to £1,134 plus equal pay increments

Assistant, Grade B Men, £682 10s by £26 5s to £1,076 5s, Women, £609 by £21 to £861, plus equal pay increments

Placing on scale dependent on approved industrial and teaching experience and, in case of Grade B Assistant, there will also be additions for degree and training

Application form, *returnable within fourteen days of appearance of this advertisement*, and details from Registrar, College of Technology, Ashley Down, Bristol 7

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY

GLASGOW

DEPARTMENT OF CHEMICAL TECHNOLOGY

Applications are invited for

LECTURESHIP IN CHEMICAL TECHNOLOGY

from candidates possessing good Honours Degree in Chemistry, Applied Chemistry, Chemical Engineering or related subject Industrial chemical plant experience a strong qualification Other qualifications sought include a higher degree, teaching and research experience, or a mathematical bias Research work encouraged for which there are excellent facilities Salary on scale £900 by £50 to £1,350 by £75 to £1,650 Application forms from the Secretary-Treasurer, George Street, Glasgow, C 1

WOOLWICH POLYTECHNIC

Applications invited for a Research Assistant in Mathematics Department The canditate appointed will be expected to read for an M Sc or Ph D (Internal) Degree of London University in the field of Elasticity The Assistantship is tenable for two or three years and has a value of £440–£600 a year Particulars and application form from Clerk to Governors

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McMASTER UNIVERSITY

Applications are invited for positions in Physical Chemistry and in Organic Chemistry at McMaster University, Hamilton, Ontario for September, 1959 or September, 1960 Appointments will be made at a rank and salary appropriate to qualifications Preference will be given to recent graduates with postdoctoral experience There are excellent facilities for research including a one megawatt swimming pool reactor

Inquiries should be directed to D B MacLean, Chairman, Department of Chemistry

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UNIVERSITY OF CAMBRIDGE

SCHOOL OF VETERINARY MEDICINE

Research Assistant, science graduate, required to carry out experimental work on animal blood-groups Previous experience in serology and blood-group studies necessary

For particulars apply to the Administrative Secretary, School of Veterinary Medicine, Madingley Road, Cambridge

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MOREDUN INSTITUTE

EDINBURGH

Experimental Officer (male) for Biochemistry Department Should have experience of biochemical research Science Degree or A R I C preferred Salary range £980 to £1,200 F S S U

Full particulars and names of two referees to The Secretary, Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh, 9

UNIVERSITY OF CANTERBURY

CHRISTCHURCH, NEW ZEALAND

LECTURESHIP IN CIVIL ENGINEERING

Applications are invited for the above position Applicants should have a degree in Civil Engineering of a recognised University, teaching experience at a University, or have held a responsible position in a branch of Civil Engineering The salary will be at the rate of £1,025 per annum, rising by annual increments of £50 to £1,275 per annum Commencing salary will be in accordance with qualifications and experience An allowance is made towards travelling expenses

Further particulars and information as to the method of application may be obtained from the Secretary,Association of Universities of the British Commonwealth, 36, Gordon Square, London, W C 1 Applications close in New Zealand and London on September 30th, 1959

UNIVERSITY COLLEGE OF RHODESIA AND NYASALAND

Applications are invited for a Lectureship in Botany from candidates with special interest in Plant Physiology Salary scales Assistant Lecturer £1,050 by £50 to £1,200 per annum, Lecturer (Grade II) £1,200 by £50 to £1,450 per annum, (Grade I) £1,450 by £50 to £1,750 per annum, entry point determined by qualifications and experience Superannuation Scheme Passages to Salisbury for appointee, wife and dependent children on appointment with allowance for transport of effects Unfurnished accommodation at rent of 15 per cent of salary Assistance given for triennial leave overseas

Detailed applications (six copies) naming three referees by August 30th, 1959 to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W C 1, from whom further particulars may be obtained

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UNIVERSITY COLLEGE, DUBLIN

Applications are invited for the post of Academic Assistant in the Department of Chemistry to hold office from October 1st, 1959 The successful candidate will be expected to have a Ph D degree, preferably on the inorganic side, and some experience in lecturing to large classes The initial salary is £850 per annum and there are prospects of promotion to Assistant—and eventually to College-Lectureships The pension scheme is non-contributory and family allowances are given Fees are paid for examination work

Further particulars may be obtained from the Secretary and Bursar, University College, Earlsfort Terrace, Dublin, who will accept applications, which should show the names of two referees, up to September 1st, 1959

UNIVERSITY OF TASMANIA

AUSTRALIA

LECTURESHIP OR SENIOR LECTURESHIP IN FLUID DYNAMICS

The University invites applications for the above position The salary grades for Lecturers are Grade II £A1,450 by £A60 to £A1,630 and Grade I £A1,630 by £A60 to £A2,050, and for Senior Lecturer £A2,150 by £A60 to £A2,510 Appointment will be offered within one of these grades according to qualifications and experience

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W C 1, Applications close in Australia and London on 14th September 1959

MEDICAL RESEARCH COUNCIL require a young graduate, with a First or good Second Class honours degree in physics, chemistry or engineering, for their PNEUMOCONIOSIS RESEARCH UNIT, Cardiff, for interesting research into the effect of environmental conditions (especially dust) on the health of workers, in collaboration with the Department of Occupational Health at the London School of Hygiene, where an initial training period will be provided Salary within range £700–£850 per annum, according to qualifications and experience Superannuation provision Apply Director, Pneumoconiosis Research Unit, Llandough Hospital, Penarth, Glamorgan

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UNIVERSITY COLLEGE HOSPITAL MEDICAL SCHOOL

Research Assistant required in Pathology Department Graduate in biochemistry or biology Salary according to experience

Application to Secretary, University College Hospital Medical School, University Street, London, W C 1

UNIVERSITY OF BRITISH COLUMBIA

DEPARTMENT OF PHYSICS

Applications are invited for permanent and also temporary positions for the Session commencing in September, 1959 Full particulars and a descriptive booklet available upon request Applicants are requested to send information regarding training and experience The undersigned will be in London from September 1st to 4th inclusive for interviews London Address c/o B C House, 1–3 Lower Regent Street, S W 1

For further information write G M Shrum, Head, Department of Physics, University of British Columbia, Vancouver, Canada

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NORTHERN POLYTECHNIC

HOLLOWAY, LONDON, N 7

Applications are invited from honours graduates in physics for appointment as research assistant for problems concerned with fast particle techniques, gas discharges, spectroscopy or electronics The candidate appointed can qualify by research for the Ph D degree Rate of pay—approximately £480 per annum

Further particular and form of application obtainable from the Clerk to the Governors

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UNIVERSITY OF SOUTHAMPTON Technician or Junior Technician (male) required in the Department of Botany, to have special responsibility for mycology, with some general laboratory duties Previous experience not necessary, training in mycological techniques will be given Salary scale Technician £440 by £20 to £590 per annum, with superannuation and sick pay scheme, Junior Technician £3 14s 6d per week at 16, rising to £7 9s 6d at 23, with prospects of promotion Starting date on or after July 6th, 1959 (existing holiday arrangements will be respected)

Written applications, stating qualifications and giving the names of two referees, should be sent to the Professor of Botany, The University, Southampton, within two weeks of the appearance of this advertisement

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WOLVERHAMPTON AND STAFFORDSHIRE COLLEGE OF TECHNOLOGY

Principal Robert Scott, M A , B Sc , Dip Ed

DEPARTMENT OF APPLIED SCIENCE

Assistant Grade B in Physics

Applicants should be honours graduates in physics, and have had suitable teaching, research or industrial experience The person appointed will be expected to teach some advanced level mathematics Experience in some branch of applied physics would be an added advantage

Assistant Grade B in Chemistry

Applicants should have a good honours degree or equivalent, together with teaching, research or industrial experience The person appointed will be required to teach inorganic chemistry to H N C and G R I C Part I standard

Salary Men, £682 10s by £26 5s to £1,076 5s per annum, Women, £609 by £21 to £861, plus equal pay additions Additions for training, degree and appropriate experience Application forms and further particular (s a e) from the undersigned, to whom applications should be returned within two weeks

G W R LINES,
Clerk to the Joint
Education Committee

Education Offices,
North Street, Wolverhampton

SWAZILAND

AGRICULTURAL RESEARCH OFFICERS

Vacancies exist for (i) Cotton and Grain Crop Research Officer for team research investigations into the agronomy of cotton and grain crops with emphasis on variety testing, (ii) Horticulture and Citriculture Research Officer for team research investigations in citriculture and horticulture with special reference to irrigated crops in a subtropical area Candidates for either post must have a university degree in Agriculture, Horticulture or Botany and preferably with some post-graduate research experience Appointments are on contract/gratuity terms but with good prospects of conversion to permanent and pensionable terms in due course Salaries are in scale £660–£1,515 plus a cost of living allowance Free passages for officer, wife and children up to equivalent of four adult passages on appointment and up to equivalent of three adult passages on leave Furnished accommodation available at moderate rental

Apply, stating name in full and giving brief details of qualifications and experience, to Director of Recruitment, Colonial Office, London, S W 1, quoting BCD 63/76/013/C1

SENIOR TECHNICIAN, HISTOLOGICAL (Category I or II according to qualifications and experience) or Technician, required in Neuropathology Department at Fountain Hospital for research into Mental Deficiency Experience in Neuropathology an advantage Salary according to qualifications and experience

Applications giving full particulars of qualifications, experience and names and addresses of two referees to be sent to Group Secretary, Fountain Hospital, Tooting Grove, London, S W 17

UNIVERSITY OF MALAYA

(SINGAPORE DIVISION)

Applications are invited for Chair of Chemistry Salary between £2,268 and £2,548 per annum, at fixed point determined by qualifications and experience Allowances expatriation £378 per annum, cost of living £210–£560 per annum Passages for appointee, wife and children under 12 years Part-furnished quarters at reasonable rent Provident Fund Scheme

Detailed applications (10 copies) naming three referees by September 30th, 1959, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W C 1, from whom further particulars may be obtained

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RE-ADVERTISEMENT

HUDDERSFIELD COLLEGE OF TECHNOLOGY

Principal Dr W E Scott, M B E

DEPARTMENT OF CHEMISTRY, COLOUR CHEMISTRY AND DYEING

Required September 1st, 1959 or as soon afterwards as possible Assistant Grade "B" to assist in the teaching of Physical and Inorganic Chemistry An active interest in research, together with experience in teaching and/or industry is desirable The salary (Burnham Scale) rises to a maximum of £1,025 per annum (Women £820 plus equalisation pay), plus allowances for graduate status (£75 or £125 Men, £60 or £100 Women) and training (£25 to £75 Men, £20 to £60 Women) All amounts subject to 5 per cent special addition The commencing salary will depend upon qualifications and experience and may include up to 12 increments in respect of approved service in industry

Further particulars and forms of application, which must be returned as soon as possible, obtainable from the Principal

H GRAY,
Clerk to the Governors

UGANDA NATIONAL PARKS

VACANCY FOR DIRECTOR

Applications are invited for the post of Director of the Uganda National Parks which will become vacant on or about July 1st, 1960 Conditions and terms of service will be by arrangement but will include a salary of not less than £2,000 per annum, free housing, contributory retiring benefits, overseas leave for persons not ordinarily resident in East Africa Preference will be given to applicants with a university degree in natural science and with African experience but such qualifications will not be necessary for appointment

Applications giving details of experience and the names of two referees should be sent to the Chairman, Uganda National Parks, P O Box 50, Entebbe, Uganda, reach him before September 15th, 1959

UNIVERSITY OF CANTERBURY

CHRISTCHURCH, NEW ZEALAND

ASSISTANT LECTURER IN BOTANY

Applications are invited for the above position Candidates should have an Honours degree in Botany Preference will be given to applicants with experience in mycology, but consideration will also be given to applicants with interests in other fields The salary will be at the rate of £780 per annum rising by annual increments of £50 to £880 per annum An allowance is made towards travelling expenses

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W C 1 Applications close in New Zealand and London on September 30th, 1959

UNIVERSITY COLLEGE HOSPITAL MEDICAL SCHOOL

Experienced male technician required to assist in research project in the Department of Chemical Pathology from 1st September, 1959 Salary, Whitley Council Scales Apply in writing to the Secretary, University College Hospital Medical School, University Street, London, W C 1

UNIVERSITY OF CANTERBURY
CHRISTCHURCH, NEW ZEALAND
ASSISTANT LECTURER IN GEOLOGY

Applications are invited for the above position Candidates should have an Honours degree in Geology and be able to lecture in Historical Geology and Micro-palaeontology The salary attached to the position will be at the rate of £780 per annum rising by annual increments of £50 to £880 Commencing salary will be in accordance with qualifications and experience An allowance is made towards travelling expenses

Further particulars and information as to the method of application are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W C 1 Applications close in New Zealand and London on September 30, 1959

UNIVERSITY OF BRISTOL
DEPARTMENT OF CIVIL ENGINEERING

Applications are invited for a Lectureship (Grade III or II) in the Department of Civil Engineering Applicants should have a good honours degree and some practical experience, preferably in the field of structural steelwork It is desirable that candidates should be under 35 years of age and have some teaching experience Salaries will be in accordance with the following scales Assistant Lecturer (Grade III) £700 to £850, Lecturer (Grade II) £900 to £,1300 (bar) to £1,650 The appointment is to be made as soon as possible and the successful candidate will be required to take up duty not later than January 1, 1960

Applications, including the names of two persons to whom reference may be made, should be sent to the Registrar, The University, Bristol, 8, from whom further particulars may be obtained

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UNIVERSITY OF CANTERBURY
CHRISTCHURCH NEW ZEALAND
ASSISTANT LECTURER IN CHEMISTRY

Applications are invited for the above position The salary attached to the position will be at the rate of £780 per annum, rising by annual increments of £50 to £880 per annum Commencing salary will be in accordance with qualifications and experience An allowance is made towards travelling expenses

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W C 1 Applications close in New Zealand and London on September 30, 1959

UNIVERSITY OF CANTERBURY
CHRISTCHURCH, NEW ZEALAND
LECTURESHIPS IN CHEMISTRY

Applications are invited for lectureships within the Department of Chemistry There are two vacancies and applicants should have special qualifications or experience in either Inorganic or Organic Chemistry The salary range is £1,025 to £1,275 per annum, rising by annual increments of £50 and the initial salary will depend on qualifications and experience An allowance is made towards travelling expenses

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 The closing date for the receipt of applications in New Zealand and London is September 30, 1959

UNIVERSITY OF LONDON
READERSHIP IN ORGANIC CHEMISTRY AT BIRKBECK COLLEGE

The Senate invite applications for the Readership in Organic Chemistry tenable at Birkbeck College (salary £1,475 to £1,775 to £2,150 a year plus £80 London Allowance)

Applications (10 copies) must be received not later than September 15, 1959 by the Academic Registrar, University of London, Senate House, W C 1, from whom further particulars may be obtained

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UNIVERSITY OF BIRMINGHAM
CHAIR OF CHEMICAL ENGINEERING

Applications are invited for the Chair of Chemical Engineering, together with the Headship of the Department of Chemical Engineering This post will be made vacant by the retirement of Professor F H Garner, O B E , on September 30th, 1960

Applications (three copies), with full details of qualifications and experience, together with the names of three referees, should be sent, by October 15th, 1959, to the Registrar, The University, Birmingham, 15, from whom further particulars may be obtained

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UNIVERSITY OF CANTERBURY
CHRISTCHURCH, NEW ZEALAND
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Applications are invited for the above position It is hoped to appoint someone who is prepared to work in the field of the solid state, but applications will be considered from persons with experience and interest in other fields The salary will be at the rate of £1,025 per annum, rising by annual increments of £50 to £1,275 per annum Commencing salary will be in accordance with qualifications and experience and an allowance will be made towards travelling expenses

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 Applications close in New Zealand and London on September 30, 1959

SCIENTIST or scientific technologist required for work on treatment of coke oven effluents and other investigations connected with the carbonisation of coal Qualifications of at least H N C in Chemistry are essential, and preference will be given to those holding a degree or A R I C The successful candidate will work at the Avenue Carbonisation and Chemical Plant of the N C B near Chesterfield It is envisaged that the initial appointment will be at not less than £700 in a scale whose maximum will be fixed according to qualifications The post is superannuable

Please apply, within seven days, giving age and full details of qualifications, experience, and present post to Divisional Chief Staff Officer, National Coal Board, East Midlands Division, Sherwood Lodge, Arnold Nottingham quoting S V 1000

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Salary and conditions of service as laid down in P T A Circular No 71 as approved by the Whitley Council

Applications, together with the names of two referees, should be addressed to the Secretary, Liverpool Radium Institute, Management Committee, 1 Myrtle Street, Liverpool, 7, not later than seven days after the appearance of this advertisement

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GOVERNMENT OF NORTHERN IRELAND
CIVIL SERVICE COMMISSION

Applications are invited for two permanent and pensionable posts of Scientific Officer in the Department of Industrial and Forensic Science, Ministry of Commerce) (1) Biologist with botany as a)principal subject (2) Chemist For this post a knowledge of pharmacy or food and drugs would be an advantage For both posts an appropriate first or second class honours degree or an approved equivalent qualification is required Salary scale £635–£1,120 Entry point will be determined according to the qualification and experience of the successful candidates Preference for ex-Servicemen

Further particulars and application forms obtainable from the Secretary, Civil Service Commission, Stormont, Belfast, should be returned by September 2, 1959

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Detailed applications (eight copies) naming three referees by September 30, 1959 to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W C 1, from whom further particulars may be obtained

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It is desirable that the appointee should commence duty early in 1960, and preferably not later than March 1

Conditions of appointment may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1

Applications close, in Australia and London, on September 15, 1959

UNIVERSITY OF SOUTHAMPTON, Zoology Department Research Assistant required from October 1, 1959 to investigate effects of chemical pollutants on marine organisms Good degree in biological science or physiology and some research experience essential Maximum salary £550 according to qualifications

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A REACTIVE NETWORK DESIGNER is required Applicants should have had three to five years' experience in the design of filters and reactive networks for wide band carrier telephone systems or in some closely allied field and also an appropriate formal academic training They must be fully conversant with the latest design methods including those applicable to crystal filters and able to take full responsibility for this section of the work of the Development Laboratories, including charge of the small group of men engaged on this work

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PHYSICIST TULLIS, RUSSELL AND CO Ltd , Paper Manufacturers, require a Physicist or Electrical Engineer to undertake development work in dielectrics and allied fields Previous experience of work in similar lines desirable but not essential Salary according to qualifications —Applications, giving details of qualifications and experience to the Secretary, Tullis, Russell and Co Ltd Markinch, Fife, Scotland

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LONDON, S W 1
Quote Ref 60/59 N

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Personnel Manager, Metropolitan-Vickers Electrical Co Ltd, Trafford Park, Manchester, 17

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LIBRARY ASSISTANT (FEMALE) WITH good knowledge of German required for Metallurgical Library in Slough, Bucks Duties include Abstracting of Technical Articles, Translations, general Library and Information work and Typing —Please apply, giving full details of experience to Box No 803, T G Scott and Son Ltd, 1 Clement's Inn, London, W C 2

IMPERIAL CHEMICAL INDUSTRIES Limited Pharmaceuticals Division, has a vacancy on the established staff of the Alderley Park Research Laboratories in Cheshire for a male or female Laboratory Technician with experience in Histology up to the standard of the Diploma in Pathological Technique of the I M L T, the possession of which would be an advantage Applicants for this appointment should preferably be below the age of thirty —Applications, with full particulars, should be addressed to the Staff Manager Imperial Chemical Industries Limited, Pharmaceuticals Division, Fulshaw Hall Wilmslow, Cheshire

HIGH DUTY ALLOYS LTD, RESEARCH Division, Slough, Bucks Physical Metallurgist or Physicist required for fundamental research on the phenomena associated with fatigue and creep of light alloys Candidates should have an honours degree and preferably some experience of university research, and be under 30 years of age The work will be in a modern and very well equipped laboratory, and encouragement is given for the publication of results A generous salary, depending on qualifications and experience is available, and there is also a Pension Scheme in operation —Please write, giving full details to the Staff Manager, address as above

LARGE CONTINENTAL PHARMACEUTICAL COMPANY requires the services of a well qualified scientist in the medical or pharmacological field to fill an important post in the sphere of international research The holder would be required to travel extensively, maintaining contact with research centres and attending medical congresses in connection with new drug development The successful candidate would live on the continent and a knowledge of the French language would be desirable The situation will be amply remunerated

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GRANTS & SCHOLARSHIPS

UNIVERSITY OF LONDON
GRANTS FOR RESEARCH

Applications are invited from members of the University and teachers in Schools of the University for grants from the Central Research Fund to assist specific projects of research and for the provision of special materials and apparatus Grants are not made for normal maintenance Applications must next be received not later than 31st August Forms of application and further particulars may be obtained from the Secretary to the Central Research Funds Committee, University of London, Senate House, London, W C 1

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A few research bursaries exist for Physicists, Chemists or Metallurgists with good honours degrees for higher degree work on (a) deformation characteristics of ceramics (b) properties of oxide films (c) structure of liquid alloys (d) transmission electron microscopy Minimum value £400 per annum plus fees

Applications to Professor J G Ball, Metallurgy Department, Imperial College, London, S W 7

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Candidates, with a good Honours degree in biological subjects, are invited to write to the Director of Recruitment, Colonial Office, London, S W 1, for the necessary application form quoting BCD356/236/01

MISCELLANEOUS

HUMANISM—A MODERN OUTLOOK — Write Ethical Union, 13 Prince of Wales Terrace, W 8

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LETTERS TO THE EDITORS

PHYSIOLOGY

An Exteroceptive Block to Pregnancy in the Mouse

EXPERIMENTS on the effect of certain oral progestogens during early pregnancy, in continuation of previous observations[1] on non-pregnant animals, involved placing a recently mated female receiving oral progestogen with a strange male In a number of the mice the procedure resulted in failure of pregnancy from the first mating and a new mating within 3–6 days Control experiments showed that the same effect was produced by dosage with inert material or even without any treatment other than the introduction of a strange male at 24 hr after mating 20 out of 49 females behaved in this way, a far greater proportion than could be attributed to the expected incidence of anovular cycles Only about 8 per cent of young females, as used, return to œstrus within 4–5 days if removed from the male after their first mating, or copulate again at this time if they are left with the male Moreover, among the suspect females there was a failure of the pseudopregnancy which might have been due to poor stud males Experiments were therefore undertaken to explore this effect

Two test situations were devised Situation *A* was as already mentioned, that is, the recently mated female was paired with a strange partner 24 hr after copulation with the stud male Situation *B* was one of proximity without contact, the female being housed in a small cage inside a stock box containing other mice which could climb about the cage but not enter it

The stud males and all the females were albinos The test males were either albino or wild-type Young virgin females were mated in pairs with a stud male , the females were removed from the male when the vaginal plug was found and housed together overnight 24 hr later they were presented with the test situation The females were generally left in the test situation for 7–10 days, and they were then removed to normal mouse boxes The pregnant females were isolated before parturition, and females which became pseudopregnant or in which the pregnancy had been blocked received a fertility test with a stud male The few females which proved to be infertile were excluded Daily vaginal smears were examined

The results of these investigations are briefly summarized in Table 1

Table 1 PREGNANCY BLOCK IN THE MOUSE

The females were separated from stud males on finding vaginal plug, and housed together until presented with the test situation 24 hr later

Test situation	Females having blocked pregnancies	
	Proportion	Per cent
A Housed with		
Strange normal male (albino)	19/69	28
Strange wild-type male	25/35	71
Castrated male (albino)	13/50	26
Another female (parous or ovariectomized)	0/48	—
Original stud male	0/32	—
B Proximity without contact that is, in cage inside stock box containing		
Albino males	8/32	25
Wild-type males	52/68	76
Females	0/49	—

Pregnancy was blocked and implantation inhibited in nearly 30 per cent of females by the introduction of a strange male within 24 hr of coitus , it was so blocked even by the presence of a castrated male Pregnancy was not affected by the return of the female to her original stud male or by the presence of a strange female, whether parous or ovariectomized Contact between the sexes was not necessary for this effect Pregnancy was also blocked when the female was caged inside the male stock box Among parous females, pregnancy was less readily blocked than among non-parous by contact with a strange male, but apparently broke down as easily when the female was housed inside the male stock box This suggests that the latter situation supplies a stronger stimulus

In both test situations the superiority of the wild-type males over the albinos as pregnancy blocking agents was highly significant The reason for this difference is not understood, and as yet male mice of other strains have not been tried Two different strains of females, one albino and the other pink-eyed champagne, were tested in small numbers in situation *B* Both exhibited pregnancy block in similar proportions to those found for the original mice

The use of the genetically marked wild-type test males showed that superfœtation did not occur Of 35 females, 15 mated with the test male All 15 gave birth to black-eyed young only (123 young) This includes one female in which coitus with the test male took place within a few hours of introduction, her litter of 8 black-eyed young being born 19 days later, 20 days after finding the vaginal plug from the stud albino male

No mutual reaction between females as regards pregnancy block was indicated either when the test situation involved other females or when the mated females were themselves placed singly, in pairs, or in threes in the test situation It is well established, however, that females exert a powerful effect upon one another in terms of the œstrous cycle[2] and the incidence of mammary cancer[3], and that the presence of a male tends to synchronize the cycle of non-pregnant females[4]

Further experiments designed to throw light on the mechanism involved in this pregnancy block of exteroceptive origin are in progress The pituitary and the hypothalamus are probably both implicated

HILDA M BRUCE

Division of Experimental Biology,
National Institute for Medical Research,
Mill Hill,
London, N W 7

June 18

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[1] Bruce, H M , *Studies on Fertility*, **10**, 158 (1958)

[2] Lee, S van der, and Boot, L M , *Acta Physiol Pharm Neerl* , **4**, 430 (1955) , **5**, 213 (1956) Whitten, W K , *J Endocrinol* , **14**, 160 (1956) , *Nature*, **180**, 1436 (1957) , *J Endocrinol* , **17**, 307 (1958) Dewar, A D , *ibid* , **18**, 186 (1959)

[3] Mühlbock, O , *J Endocrinol* , **17**, vii (1958)

[4] Whitten, W K , *J Endocrinol* , **13**, 399 (1956)

Retinal Responses of Pink Salmon associated with its Downstream Migration

THE seaward migration of juvenile Pacific salmon is usually nocturnal and confined to a relatively brief portion of the night[1] It has been suggested that "as the light intensity falls rheotactic responses, which are to a large degree dependent on vision, fail, and these fish pass down stream in shoals The fact that such mass movements occur during a rather precise period of the night is probably due to the dark adaptation of the eye and a period of night blindness"[2] In support of this view, a recent histophysiological examination of the retinæ from several species of *Oncorhynchus* has shown an incompletely dark-adapted condition of the retinæ at the time of most active downstream migration[3,4] As a further test of this hypothesis, the retinæ from fish killed at different light intensities during the evening and early morning have been compared with the retinæ from fish which were completely adapted to the same light intensities in the laboratory The pink salmon fry (*Oncorhynchus gorbuscha*), probably the most specialized of the downstream migrant salmon[1], was selected for the study

Migrant pink salmon were collected from a trap in Jones Creek, British Columbia, and brought into a dark room of the laboratory Groups of five fish were exposed for 90 min to each of seven light intensities, ranging evenly from 10^2 to 10^{-4} ft -candle The period of exposure was sufficient to bring about a complete adaptation[3,4] Fish captured in the same place and in like manner were placed in glass aquaria which were located in an exposed position in the river where the fish had been migrating The bottoms of the aquaria were covered with sand and gravel From these aquaria, fish were sampled at seven times when the incident light intensity reached the same values used in the laboratory This was done both at twilight and at dawn Light intensities of 10^{-1} ft -candle and greater were measured with 'Photovolt' model 200 photometer and light intensities below this value with 'Photovolt' model 520-*M* electronic photometer

The eyes of teleost fish adapt themselves to altered light conditions by pronounced changes in the distribution of the retinal epithelial pigment and the position of the rods and cones When the light intensity falls below threshold values the retinal pigment concentrates and the rods and cones migrate due to the contraction and expansion, respectively, of their myoids These movements are in direct proportion to the logarithm of the light intensity Thus in bright light, the rods are shielded by the pigment and the cones placed directly in the path of light, whereas in low light intensities and darkness, the rods are brought directly in the path of light and the cones migrate closer to the concentrated pigment These processes can be followed by measuring the thickness of the pigment and cone layers The cones are more obviously delimited for this purpose than the rods The histological techniques and methods of measuring retinal changes have been described[3,4] The values presented here are means for 50 measurements made from 10 eyes in each case

Fig 1 shows that both pigment and cone layers of the pink salmon retina are in a semi-adapted state during the periods when the light intensity is rapidly changing in the evening and in the morning The difference between the fully adapted laboratory picture and the semi-adapted state in Nature is less at dawn than in the evening This is in accord with an earlier demonstration that light adaptation is more rapid than dark adaptation in this species[4] Under natural conditions, in the evening, both pigment and cones are in a fully adapted state at intensities above 1 ft -candle However, between this level (the cone threshold) and 10^{-3} ft -candle the retinæ of animals fixed in the field are not as completely adapted as those in the laboratory At 10^{-4} ft -candle adaptation is the same in both groups It requires about 45 min (Fig 1) for the light intensity to fall from 1 to 10^{-4} ft -candle Ali[4] has shown that retinal adaptation commences below 1 ft -candle and requires about 45 min to reach a maximum Thus, the changes in the field are in accord with the laboratory findings With increasing light, retinal changes are evident at intensities above 10^{-2} ft -candle and adaptation is essentially complete at 1 ft -candle The rapidity of light adaptation[4] would seem to account for the small differences found in the fish sampled at dawn Actually, the changes in light intensity in Nature are somewhat more rapid at dawn than at dusk (Fig 1)

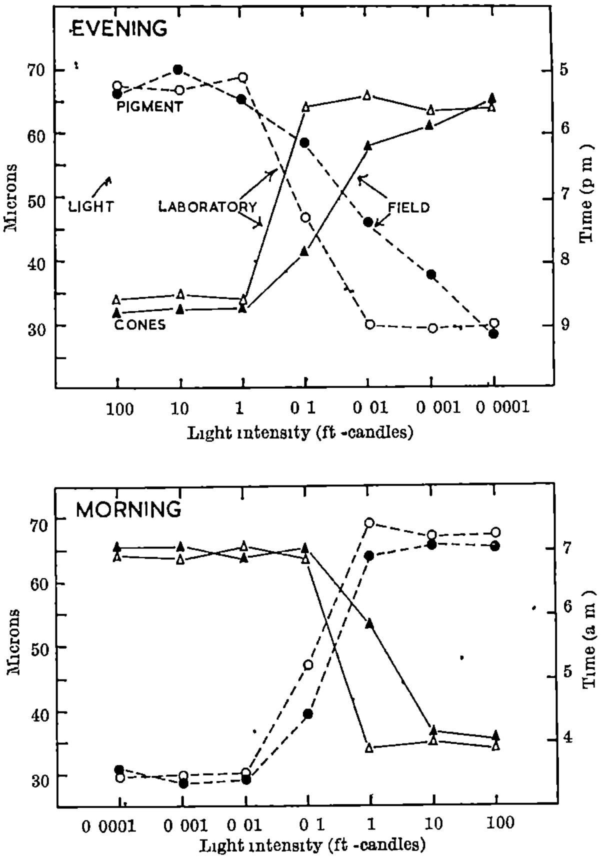

Fig 1 Thicknesses of the pigment and cone layers of pink salmon retinæ when fully adapted to a series of light intensities in the laboratory and at the same intensities under conditions of rapidly changing morning and evening light in the field

These findings are in accord with the theory that migration of pink salmon is initiated when the retina is only partially adapted to the decreasing illumination At Jones Creek, where these observations were made, it was found that 80 per cent of the pink migrants entered the trap between 7 p m and 9 p m (Pacific standard time) on the nights of the study

During this period the light intensity decreased below 1 ft -candle and reached 10^{-4} ft -candle It is not to be expected that all the fish will be affected at the same time since there are shaded and exposed areas in every stream These observations, however, support well the theory that, whether the pink salmon is transported or actively swims downstream[1,5], its nocturnal movement will be initiated when visual contact with its environment is reduced or impaired This will be associated with the rather specialized behaviour of rising to the surface of the water at low light intensities[1]

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[1] Hoar, W S , *J Fish Res Bd Canada*, **15**, 391 (1958)

[2] Hoar, W S , *Biol Rev* , **28**, 437 (1953)

[3] Brett, J R , and Ali, M A , *J Fish Res Bd Canada*, **15**, 815 (1958)

[4] Ali, M A , Ph D thesis, Univ British Columbia (1958)

[5] Neave, F , *J Fish Res Bd Canada*, **12**, 369 (1955)

Deoxyribonucleic Acid Formation in Multiplying HeLa Cells

While studying the behaviour of parasynchronously dividing HeLa cells (Gey), Newton and Wildy[1] have measured the amount of deoxyribonucleic acid as a function of the time-interval between one division and the next Their results suggest that the synthesis of deoxyribonucleic acid occurs during two periods in interphase one soon after and one just before cell division Between these periods, in mid interphase, there exists an interval during which the amount of deoxyribonucleic acid (DNA) in the cell remains approximately constant (Fig 1, curve *a*)

Partial confirmation of this result, using a microspectrophotometric technique, has been obtained in a further series of experiments made with randomly dividing cultures Replicate cultures of HeLa cells were grown on cover-glasses held in 10-ml hard glass screw-capped bottles These were made by introducing into each bottle 1 0 ml Gey's saline containing 20 per cent human serum, 0 5 per cent lactalbumin hydrolysate (Nutritional Biochemicals Inc), 100 units/ml penicillin, 100 mgm /ml streptomycin and 0 002 per cent phenol red in which were suspended 250,000 separated cells After incubating at 37° C for 36 hr the cultures were fixed in methanol, stained by the Feulgen technique and the amount of chromophore per cell was measured for 70 cells (from two different cultures) by the two wave-length technique[2],[3], using the microspectrophotometer made by M L Mendelsohn[4] in the Department of Radiotherapeutics, Cambridge From these measurements a histogram has been constructed which shows the distribution of the chromophore, and hence the relative amounts of deoxyribonucleic acid, among the individual cells of the culture (Fig 2)

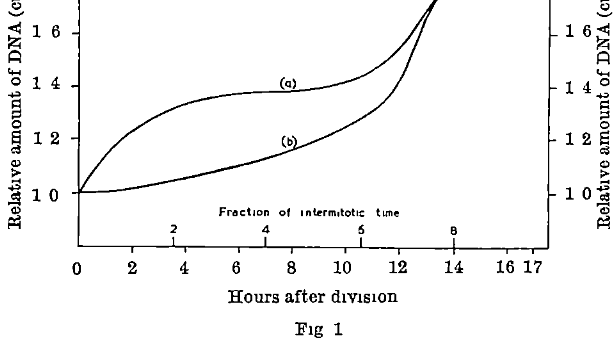

Fig 1

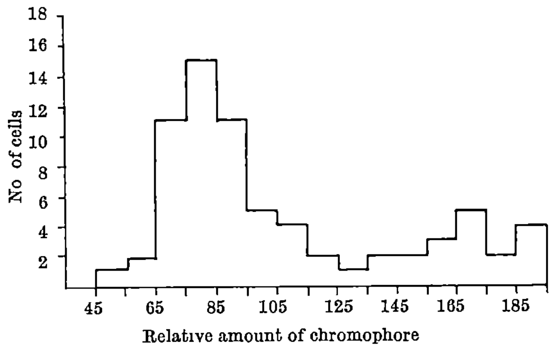

Fig 2

Walker[5] has shown how the synthesis curve for deoxyribonucleic acid may, with certain restrictions, be constructed from such a histogram It is believed that the cultures used for the estimation satisfied these conditions Fig 1, curve *b*, has therefore been constructed from the histogram of Fig 2

Comparing the curves in Fig 1, it will be seen that whereas it is not possible to tell from Fig 1*b* whether the early formation of deoxyribonucleic acid shown in Fig 1, curve *a*, occurs, there is certainly a rapid synthesis beginning about 5 hr before cell division and continuing up to a comparatively short time before cell division

The late period of formation of deoxyribonucleic acid agrees with the findings of Walker and Yates[6] using other kinds of cells and with those of Painter and Drew[7] using tritiated thymidine on cultures of growing HeLa cells

It is, however, difficult to explain the failure to detect the earlier rise in deoxyribonucleic acid which was found with parasynchronously dividing cultures, though the following two explanations should be considered (1) that the present method is inadequate for demonstrating such a rise , (2) that the early rise is characteristic only of parasynchronously dividing cells The latter explanation is thought to be more likely because in such cultures the early rise in deoxyribonucleic acid has never been observed before the first cell division has occurred

A limit to the end of the synthesis period has been obtained by examining autoradiographs of cultures growing in the presence of tritiated thymidine After 36 hr growth, tritiated thymidine (Schwarz 3 0 c /mM) was added to the medium to give a concentration of 1 μc /ml and, 30 min later, the culture was fixed in methanol The cells were afterwards stained with gallocyanin and autoradiographs were prepared In these, although interphase cells were well labelled, examination of several hundred cells in all stages of mitosis showed that none of them was labelled From this it can be deduced that synthesis of deoxyribonucleic acid ends at least 1–1¼ hr before the commencement of mitosis, since the cells were in the thymidine for ½ hr. and the duration of mitosis is about 35 min.

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[1] Newton, A. A., and Wildy, P., *Exp. Cell Res.*, **16**, 624 (1959).
[2] Patau, K., *Chromosoma*, **5**, 341 (1952).
[3] Ornstein, L., *Lab. Invest.*, **1**, 250 (1952).
[4] Mendelsohn, M. L., Ph.D. thesis, Cambridge University (1957).
[5] Walker, P. M. B., *J. Exp. Biol.*, **31**, 9 (1954).
[6] Walker, P. M. B., and Yates, Helen B., *Proc. Roy. Soc.*, B, **40**, 274 (1952).
[7] Painter, R. B., and Drew, R. M., *Lab. Invest.*, **8**, 278 (1959).

Induction of Parthenocarpy in *Rosa arvensis* Huds. with Gibberellic Acid

As has been previously reported[1], parthenocarpy may be induced in the two non-apomictic species, *R. rugosa* Thunb. and *R. spinosissima* L., by means of α-naphthaleneacetic acid, α-naphthaleneacetamide and 2,4,5-trichlorophenoxyacetic acid. Similar experiments were carried out in an attempt to induce parthenocarpic development in a third non-apomictic species, *R. arvensis*.

The auxin was applied in two ways to the unopened flower-bud, which was emasculated by cutting off the 'disk' (including the head of stigmas) immediately prior to treatment. In early experiments aqueous solutions of the auxins mentioned above and indole-acetic acid were injected into the cavity of the receptacle in concentrations ranging from 2 to 25 p.p.m. In later work the auxin was applied to the cut surface as a lanolin paste in concentrations of 0·025–1·0 per cent. Since *R. arvensis* differs from the other two species in having a much lower ascorbic acid content[2,3], additional mixtures, including ascorbic acid, were used.

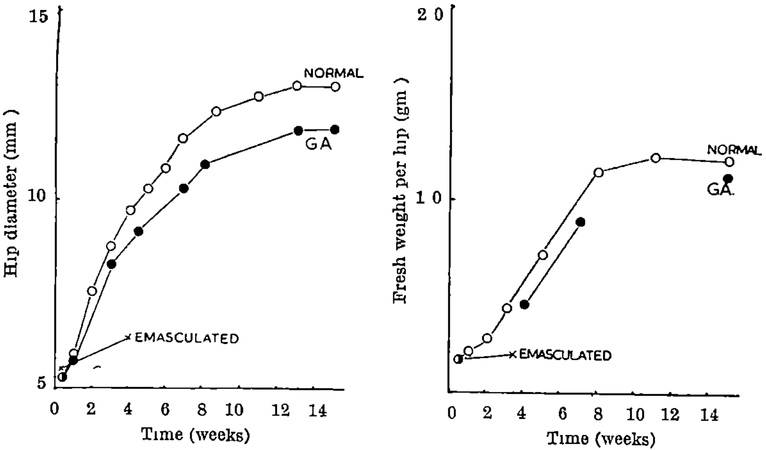

Fig. 1. The growth in terms of average diameter and fresh weight of normal hips, ○—○; emasculated flower-buds ×—×; and emasculated flower-buds treated with 1·0 per cent gibberellic acid in lanolin, ●—●

Almost all these experiments produced negative results, the emasculated control hips usually surviving longer than those treated with auxin. Out of a total of about 300 buds treated, only four showed any signs of growth; these had received the lowest concentration of auxins in lanolin and two of them had had ascorbic acid.

Since the development of rosaceous fruit after fertilization is characterized by increase in cell size rather than in cell number, the properties demonstrated for gibberellic acid suggested that it might be effective in inducing parthenocarpic development. In February 1958 parthenocarpic hips of *R. rugosa* were produced in the greenhouse by the application of gibberellic acid and shortly afterwards similar results were recorded for *R. spinosissima*[1].

In June 1958, 200 flower buds on a bush of *R. arvensis* were emasculated and 1·0 per cent gibberellic acid in lanolin was applied. Control groups of normal and emasculated buds were also selected; it had previously been shown that the application of lanolin alone produced no response. Samples from each group were harvested at intervals for determinations of fresh and dry weight, and Fig. 1 shows the development of the different groups of hips in terms of average hip diameter and fresh weight.

The main period of fruit-drop in *R. arvensis* is 3–5 weeks after flowering; 46 days after treatment with gibberellic acid 107 out of 150 hips were developing parthenocarpically, which represented a fruit-set of 71 per cent compared with 45 per cent for the normal, fertilized hips under these field conditions. None of the emasculated buds developed. Of the 57 parthenocarpic hips allowed to remain until maturity at 14 weeks after treatment, 48 had the appearance of normal, ripe hips while the other nine were smaller and not fully pigmented.

The *Triticum* coleoptile straight-growth test of Luckwill[4,5] showed that normal hips appear to contain two acidic, growth-promoting substances having R_F values of 0·1–0·2 and 0·4–0·5 in *iso*propanol/ammonia/water, and a neutral, growth-promoting substance with an R_F of 0–0·1 which is present in small quantities in the bud and flowering stages but which could not be detected 17 days after flowering, or in subsequent assays. None of these three substances was found in either parthenocarpic hips or emasculated controls, but a neutral growth-substance ($R_F = 0·4–0·6$) was present in the emasculated hips and an apparently identical substance was found in the parthenocarpic hips. A consistent growth-inhibitory effect was present in the tests, predominantly in the acid fraction and centred at R_F 0·8 in all stages of normal, emasculated and parthenocarpic hips.

The relationship between achene development and variations in the amount of growth regulators will be reported elsewhere.

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[1] Jackson, G. A. D., and Prosser, M. V., 109th Conference of the Society for Experimental Biology, April 1958; and in the press.
[2] Melville, R., and Pyke, M., *Proc. Linn. Soc. Lond.*, **159**, 5 (1947).
[3] Barakat, S. E. Y., Ph.D. thesis, University College of North Wales (1958).
[4] Luckwill, L. C., *Nature*, **169**, 375 (1952).
[5] Wright, S. T. C., *J. Hort. Sci.*, **31**, 196 (1956).

HÆMATOLOGY

Anti-A Hæmagglutinins from a Non-Leguminous Plant—*Hyptis suaveolens* Poit.

Certain plants, chiefly their seeds, contain agglutinins for the erythrocytes of various species. Whereas most plant agglutinins make no individual distinctions among human erythrocytes, some act selectively on one or other of the following blood-group antigens[1]: A, A_1, B, H and N. Except for separable anti-H and anti-B agglutinins from the seed capsule of certain species of *Euonymus*, of the family Celastraceae, all specific seed agglutinins have hitherto been obtained from Leguminosae[1].

An anti-A agglutinin has now been found in the seeds of *Hyptis suaveolens*, Poit, of the genus Labiatiae. The agglutinin works best when a fresh seed extract is tested on a flat tile which is gently and continuously rocked. Although it is not very avid when tested with erythrocytes suspended in isotonic saline solution, it agglutinates A_1 and A_1B cells strongly, A_2 weakly, and fails to agglutinate A_2B cells. Thus *Hyptis suaveolens* seed extract sharply differentiates A_1 and A_1B erythrocytes from those of the weaker sub-groups of A and AB; however, it is not as satisfactory for this purpose as *Dolichos biflorus* seed extract[2], which is far more avid.

The *Hyptis suaveolens* agglutinin acts as strongly at 37° C. or 4° C. as at room temperature. It does not cross-react with B or O cells after 24 hr. at 4° C. or when erythrocytes are suspended in albumin; albumin, however, potentiates the agglutination of A_2 and A_2B cells. Agglutination is inhibited by A-secretor saliva and by AB serum. A full description will be presented elsewhere.

The 'new' agglutinin is of special interest because it is the first seed anti-A (anti-A_1) agglutinin to be found outside the Leguminosae. The current trend is to confine the search for specific seed agglutinins to leguminous plants; wide examination of other plant families might be profitable.

I am grateful to D. S. Das for collecting the seeds and for technical assistance. The seeds were identified by the Botanical Survey of India, Poona.

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[1] Krupe, M., "Blutgruppenspezifische pflanzliche Eiweisskörper (Phytagglutinine)" (Stuttgart, 1956).

[2] Bird, G. W. G., *Curr. Sci.*, **20**, 298 (1951); *Nature*, **170**, 674 (1952).

Interaction of Erythrocytes and Endotoxins

Considerable diversity of opinion exists as to the sensitivity of hæmagglutination tests. The discrepancy in results may to some extent be attributed to technical differences. The factors influencing the reaction, the elution of endotoxin *in vitro* and the uptake by erythrocytes *in vivo* have been examined using a dehydrated endotoxin derived from *S. typhi* (*TO*-901). This powder consisted of 68.5 per cent ash, 7.8 per cent moisture, 1.6 per cent protein, 2.2 per cent lipids and, based on L-rhamnose hydrate as standard, 2.7 per cent rhamnose. If the method of calculation described by Webster *et al.*[1] is adopted the polysaccharide content is 14.3 per cent and the endotoxin approximately 20 per cent. The powder was dissolved in isotonic saline, heated to 56° C. for 30 min. and stored at 4° C. for at least 24 hr. before use. The solution had a slight buffer action, *p*H 7.2. Erythrocytes from healthy rabbits were washed and measured with the hæmatocrit. A volume of 0.2 ml. packed cells was used in most experiments.

Endotoxin was adsorbed on to the washed and measured erythrocytes at 37° C. for 1 hr. The cells were then washed three times in 6–8 volumes of isotonic saline and accurately made up to a 20 per cent suspension. Agglutination was performed on slides, using 0.05 ml. of sensitized erythrocytes and an equal volume of a diluted standard *TO*-serum. The slide was agitated regularly and the test read after exactly 10 min.

The amount of endotoxin adsorbed on erythrocytes was dependent on both the absolute quantity of endotoxin available and on its concentration. The speed of the process was proportional to the concentration of endotoxin and related to the temperature, being five to six times faster at 37° C. than at 4° C.

Erythrocytes coated with very small amounts of endotoxin were inagglutinable in antiserum, whereas those with greater quantities of endotoxin agglutinated readily. This afforded the basis for the determination of an 'erythrocyte-agglutinating unit', defined as the smallest amount of endotoxin, incubated with 2 ml. of 10 per cent erythrocytes for 1 hr. at 37° C., which rendered the cells agglutinable in standard serum diluted 1 in 10. One erythrocyte-agglutinating unit was found to be equivalent to 0.16 mgm. of the dehydrated powder. The quantity of crude endotoxin adsorbed on erythrocytes in these circumstances was 0.12 mgm., thus removing 75 per cent of endotoxin from the supernatant. Assuming the crude powder contains 20 per cent endotoxin it appears that 0.2 ml. of agglutinable packed cells under our experimental conditions must be coated with a minimum of 24 µgm. of endotoxin.

Erythrocytes, initially sensitized with sub-agglutinable quantities of endotoxin, became agglutinable on subsequent exposure to endotoxin provided that the sum of the two doses constituted at least one erythrocyte-agglutinating unit. Thus the erythrocytes appear to bind the adsorbed endotoxin quite firmly.

Assuming that the endotoxin was not removed or rendered undetectable except by fixation to erythrocytes, the reduction in endotoxin content as measured by determination of the erythrocyte-agglutinating unit on the supernatant, will be a direct, quantitative expression of adsorption. Experiments along these lines indicated that erythrocytes were capable of binding at least 200 times the minimum amount required for agglutination under standard conditions; that is to say 0.2 ml. packed cells could adsorb more than 200 × 24 µgm. or 4.8 mgm. of endotoxin as calculated, corresponding to 2.2 per cent of their own weight.

Erythrocytes of the same batch, coated with amounts of endotoxin ranging from 1 to 200 erythrocyte-agglutinating units, gave final agglutination titres against the standard serum ranging from 1 : 10 to 1 : 1,280. Hence, the titre of a given serum will vary according to the quantity of endotoxin adsorbed on to the cells. This may explain, at least partially, the discrepancy and inconsistency in results obtained by hæmagglutination tests; it could be overcome by rigorous standardization for which accurate measurement of endotoxin is essential.

Elution of endotoxin at our experimental conditions (*p*H 7.2–7.3) was minimal. Erythrocytes coated with 1.5 times minimum agglutinating dose of endotoxin were still agglutinable after 12 washings in saline at room temperature. Thus, on the assumption that the stability of an erythrocyte suspension is unaffected by washing, it may be concluded that elution is of a low order. Since this could not be measured in erythrocyte-agglutinating units, a technique for estimating smaller quantities of endotoxin in solution was provided by the construction of a dose-response graph in rabbits. The maximum antibody response, as measured by bacterial agglutination, was directly proportional to doses of crude endotoxin ranging from 0.01 μgm. to 1 mgm. Using the dose-response technique for endotoxin estimation, further studies on elution at room temperature showed that endotoxin was released, but that this did not amount to 1 per cent of the adsorbed endotoxin per equivalent volume of saline. Whether the eluted endotoxin originated from intact or disintegrated erythrocytes has not as yet been established; but it is noteworthy that the washings caused slight hæmolysis.

Sensitized, washed cells inoculated intravenously into non-immune rabbits were highly antigenic. A single injection of a suitably adjusted erythrocyte suspension produced, in 7–10 days, agglutination titres up to 1:100,000. The serum of a rabbit previously immunized by endotoxin produced hæmagglutination *in vitro* against its own sensitized cells. Hæmolysis occurred on the addition of complement. Intravenous inoculation of 20 ml. of 50 per cent suspension of these erythrocytes, which agglutinated *in vitro* with the recipient's serum, boosted the antibody production. The animals failed to produce an acute intravascular episode. Nor was there conclusive evidence of a hæmolytic process as measured by serum bilirubin estimations and Schumm's test. This tolerance of what is a serologically incompatible transfusion is unexplained.

In vivo sensitization in rabbits was demonstrated by intravenous injection of large doses of endotoxin. The animals were bled 4 hr. later and the erythrocytes, washed six times in excess saline, were inoculated intravenously into non-immune rabbits. They responded with a significant antibody production. Which part the adsorption *in vivo* plays in the defence against endotoxins has not as yet been established.

Details of these experiments will be published elsewhere.

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[1] Webster, M. E., Sagin, J. F., Landy, M., and Johnson, A. G., *J. Immunol.*, 74, 455 (1955).

BIOCHEMISTRY

Interaction of Sucrose Stearate with Starch

It is generally agreed that changes in the starch component of flour are responsible for the staling of bread[1]. Following a report by Bohn[2] that the sucrose stearates are effective as anti-staling agents, a study was made of the interaction of starch with a commercial sample of sucrose stearate, kindly supplied by F. D. Snell, Inc.

Addition of a sucrose stearate solution to a 1 per cent solution of 'AnalaR' starch in 0.1 per cent sodium chloride resulted in the precipitation of some starch. The maximum amount of precipitate (about 20 per cent of the weight of starch) was obtained with concentrations of sucrose stearate above 0.06 per cent.

Extension of the study to undegraded starches (Table 1) showed that the amount of precipitate depended upon the type of starch. Fractionation of the potato starch into amylose and amylopectin[3] followed by precipitation with excess sucrose stearate showed that most of the amylose but little of the amylopectin was precipitated (see Table 2). Treatment with excess sucrose stearate of an artificial mixture of amylose and amylopectin in the ratio in which they occur in starch gave a figure intermediate between that of the whole starch and that which would be expected on the basis of the separate amylose and amylopectin precipitations. These results indicate that the amylopectin is precipitated more efficiently in the presence of amylose than in its absence.

Table 1. Precipitation of Starches by Sucrose Monostearate

Type of starch	Polysaccharide concentration (per cent)	Sucrose monostearate concentration (per cent)	Precipitate (per cent of polysaccharide)
'AnalaR' starch	1.0	0.1	21.6
Potato starch	1.0	0.1	70.9
Wheat starch	1.0	0.1	92.4
Waxy maize starch	1.0	0.1	13.0

Table 2. Precipitation of Starch Fractions by Sucrose Monostearate

Type of starch fraction	Polysaccharide concentration (per cent)	Sucrose monostearate concentration (per cent)	Precipitate (per cent of polysaccharide)
Potato starch	0.4	0.04	72.7
Potato amylose	0.4	0.04	79.9
Potato amylopectin	0.4	0.04	11.1
20 per cent amylose, 80 per cent amylopectin	0.4	0.04	43.9

Controlled acid hydrolysis of potato starch showed that a high molecular weight was important in determining the amount of precipitate formed with sucrose stearate and it is likely that the low yield of precipitate from 'AnalaR' starch could be attributed to this factor.

A study of the change in diameter of wheat starch granules on heating in aqueous suspension in the presence and absence of sucrose stearate showed that the rate of swelling was reduced in the presence of sucrose stearate. From an examination of the change in turbidity on heating wheat starch suspensions (0.1 per cent), it appeared that in the presence of 0.01 per cent sucrose stearate the gelatinization temperature is raised about 10 deg.

As sucrose stearate is firmly bound by starch, it seemed likely that it would interfere with the starch/iodine reaction. This was shown to be so, and that iodine and sucrose stearate compete for the amylose fraction. There was no evidence for any marked interaction between sucrose stearate and amylopectin by this technique. It is possible that the stearate chain of the sucrose stearate molecule occupies a position down the centre of an amylose helix, in the same way that iodine does[1]

A complete account of this work will be published elsewhere

We are grateful to the Sugar Research Foundation for financing these investigations

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[1] Radley, J A , "Starch and its Derivatives", 1, 225 (Chapman and Hall, 1953)

[2] Bohn, R T , private communication to Sugar Research Foundation Inc , December 9, 1955

[3] Greenwood, C T , and Robertson, J S M , *J Chem Soc* , 3769 (1954)

Influence of X-Rays on the Activity of Carbonic Anhydrase in Erythrocytes and on their Hæmolytic Resistance

Since sickle cell anæmia is possibly related to the activity of carbonic anhydrase[1], it is of interest to find some way of inhibiting the enzyme without altering the resistance of the cell membrane Carbonic anhydrase is very stable[2] but its activity can easily be changed experimentally by adjusting the *p*H and temperature, or by adding sulphonamides or certain inorganic ions All these factors, however, have a marked influence on hæmolysis, whereas erythrocytes seem to be rather resistant to X-rays[3]. We therefore decided to examine whether carbonic anhydrase could be inhibited by a dose of X-rays which would have little or no effect on hæmolysis

For the determination of the enzyme activity we designed an improved Warburg technique[4] This method is based upon measuring the rate of evolution of carbon dioxide when a bicarbonate solution is treated with a buffer and the enzyme We calculated the unimolecular velocity constant of the reaction, which is also used as an index of activity by Mitchell, Pozzani and Fessenden[5] The standard error of our measurements was 12 per cent and for the non-catalysed reaction 4 per cent As a measure of the hæmolytic resistance we used the hæmolytic index this is, in conventional experimental conditions[6], the highest dilution of lysin which produces 100 per cent hæmolysis within 2 hr The standard error of our hæmolytic indices was 2 5 per cent Suspensions of 10^7 cells/cm^3 in physiological saline solution were irradiated in vessels of 2 cm^3, dose 100,000 r, instrument Philips 'Compactix', 210 kV, h v l = 4 mm of aluminium, dose-rate 6,700/min

In non-irradiated blood we found the following carbonic anhydrase activities, calculated per cubic centimetre of full blood ox blood, 1 85 Mitchell units, human blood, 1 4, chicken blood, 1 2 Irradiations of four samples of ox blood, two samples of human blood and two samples of chicken blood had no effect on the activity Repeating this dose after 24 hr yielded no inhibition Solutions of purified enzyme (Schering's 'Cartase', 0 1 per cent), treated in the same way, showed an inactivation of 20 and 50 per cent respectively The fact that these high doses of X-rays do affect erythrocytes in other respects, was shown by their hæmolytic index in our controls this was 13,300 with saponinum album (Merck), after irradiation, the index was increased by 10 per cent and after the second dose of 100,000 r the increase was 17 per cent

Our experiments confirm the great stability of carbonic anhydrase, and indicate that this stability is still greater inside the red blood cell we found no decrease in activity of the carbonic anhydrase of erythrocytes after irradiation with 200,000 r The hæmolytic resistance of the cells was clearly diminished by this dose, so that it is possible that irradiation by X-rays will permit us to modify the structure of the cell-membrane without altering its carbonic anhydrase activity

We wish to thank Prof R Ruyssen for advice and encouragement and Prof Van Vaerenberg, who provided the necessary X-ray equipment

This work was subsidized by the Belgian Interuniversitair Instituut voor Kernwetenschappen

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[1] Hilkovitz, G , *Brit Med J* , 266 (1957)

[2] Keilin, D , and Wang, Y L , *Biochem J* , 41, 491 (1947)

[3] Flemming, K , *Naturwiss* , 43, 87 (1956)

[4] Vander Haeghen, P , and Lauwers, A , *Natuurwetenschappelijk Tijdschrift* (in the press)

[5] Mitchell, C A , Pozzani, U C , and Fessenden, R W , *J Biol Chem* , 160, 283 (1945)

[6] Croes, R A , *Verh Kon Vlaamse Acad Wetensch , Letteren en Schone Kunsten Belgie, Kl Wetensch* , No 43 (1953)

A Method for distinguishing between α- and β-Glycosides by the use of Plant Hæmagglutinins (Lectins)

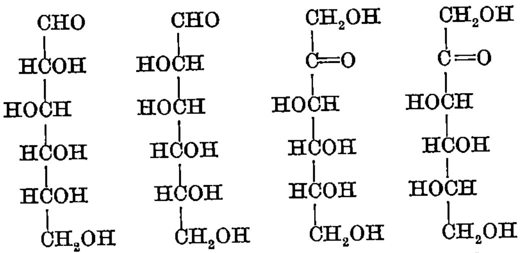
Several plant seeds contain proteins that agglutinate red blood cells[1,2] as do many antibodies For these proteins the name 'lectins' has been suggested[3] They can be as specific as animal antibodies in that they react only with erythrocytes of certain blood groups The ABO blood group specific lectins—as well as the ABO specific antibodies—are inhibited by some simple sugars, mainly components of blood group polysaccharides[1,2,4]. Several 'unspecific' lectins are also inhibited by simple sugars, but these sugars are not necessarily components of blood group polysaccharides[1,2] The explanation of this phenomenon is that the sugars, the structure of which most closely resembles the specific (sugar) group of the red cell receptor, attach themselves to the active site(s) of the lectin molecule, thus blocking them

A monosaccharide as a rule retains its inhibiting power even when linked to other sugars through the hydroxyl group of the first (in ketoses, the second) carbon atom[2,5]. The type of link, whether α or β, seems to be significant In order to throw light on this problem, I made plant agglutinin inhibition tests by a method described in detail elsewhere[6]

The following sugars were used in all experiments D-glucose, D-glucosamine, N-acetylglucosamine, D-glucuronic acid, D-gluconic acid, D-xylose, D-mannose, D-fructose, L-sorbose, D-galactose, D-galactosamine, N-acetyl-D-galactosamine, D-fucose, L-arabinose, D-talose, L-galactose, L-fucose, D-arabinose, D-ribose, D-digitoxose, L-rhamnose, maltose, sucrose, turanose, trehalose, cellobiose, gentiobiose, melibiose, raffinose, and lactose

Seeds of *Pisum sativum* L , *Cytisus sessilifolius* L , *Bandeiraea simplicifolia* Benth , and *Crotalaria juncea* L were used The lectin solutions were prepared by incubating a mixture of seed powder (1 part) and physiological saline (9 parts) for 2 hr at 37° C After centrifugation the supernatant was used 0 05 ml of seed extract containing 2–4 agglutinating doses of lectin and 0 05 ml of sugar solution (pH 7 0) in saline were mixed, and after 30 min incubation at 20° C 0 05 ml of a suspension containing 3 per cent human red cells in saline was added After 2 hr further incubation at 20° C the tubes were read for agglutination The quantitative inhibiting power of the sugars was measured by preparing two-fold serial dilutions of them

The results are shown in Tables 1 and 2 The figures give the final concentration of sugar Of the sugars tested (see above) only those which inhibit either *Pisum sativum* or *Cytisus sessilifolius* lectin at a concentration of 0 08 *M* are included in Table 1 The *Pisum* lectin is strongly inhibited by D-glucose, D-mannose, D-fructose and weakly by L-sorbose The structural differences between the first three sugars are confined to carbon atoms 1 and 2 L-Sorbose differs from D-fructose only with regard to carbon atom 5, but its inhibiting activity is far lower D-Glucuronic acid and D-gluconic acid are not inhibitory


D-Glucose D-Mannose D-Fructose L-Sorbose

It will be seen from the second part of Table 1 that α-glucosides inhibit agglutination by *Pisum* extract as effectively as D-glucose, while β-glucosides are not inhibitory Sucrose is not only an α-glucoside but a β-fructoside as well , however, the fructose part is not probably responsible for the inhibition, since another β-fructoside, raffinose, has no effect on *Pisum* lectin An agglutination by *Cytisus* extract, on the other hand, is inhibited by β-glucosides but not by α-glucosides The failure of glucose itself to inhibit the *Cytisus* lectin is difficult to explain unless it is due to the hexose molecule being too small

Table 1

Sugar		Minimum amount of sugar (m moles/l) inhibiting the action of *Pisum sativum* lectin	Minimum amount of sugar (m moles/l) inhibiting the action of *Cytisus sessilifolius* lectin
	D-Glucose	1 25	>80
	D-Glucosamine	5	>80
	N-Acetyl-D-glucosamine	2 5	>80
	D-Mannose	0 6	>80
	D-Fructose	2 5	>80
	L-Sorbose	40	>80
	(Lactose)	>80	40
α-Glucosides	Maltose	1 25	>80
	Sucrose	2 5	>80
	Turanose	0 6	>80
	Trehalose	0 6	>80
β-Glucosides	Cellobiose	>80	5
	Gentiobiose	>80	40

Table 2

		Minimum amount of sugar (m moles/l) inhibiting the action of *Bandeiraea simplicifolia* lectin	Minimum amount of sugar (m moles/l) inhibiting the action of *Crotalaria juncea* lectin
	D-Galactose	0 6	5
	D-Galactosamine	5	>80
	N-Acetyl-D-galactosamine	0 4	
	D-Fucose	2 5	20
	L-Arabinose	5	20
	D-Talose	20	
	L-Rhamnose	40	>80
α-Galactosides	Melibiose	0 3	5
	Raffinose	0 3	20
β-Galactoside	Lactose	20	1 25

It seems possible, on the basis of the above results, to ascertain the type of the glycosidic link (α or β) of D-glucose, perhaps also of glucosamine, acetyl-glucosamine, D-mannose, in disaccharides and other oligosaccharides the structure of which is only partially known

There are other lectins (*Bandeiraea simplicifolia* and *Crotalaria juncea*) by means of which it seems possible to obtain information of the type of the D-galactosidic (and perhaps D-fucosidic, L-arabinosidic, etc) link, even though the differences between α- and β-galactosides are less definite (Table 2) than differences between α- and β-glucosides (Table 1) Unfortunately the number of galactosides tested is small

If need be, the determinations can be made with 0 01–1 mgm of sugar, and the solution need not be pure , many amino-acids and other sugars, for example, do not interfere There are other methods of studying the nature of the glycosidic link, but the amount of sugar needed for enzymatic or polarimetric studies is greater The information obtained by chromatographic or infra-red spectrographic studies is limited unless an adequate stock of reference compounds is available

Of the seeds quoted above only those of *Bandeiraea simplicifolia* may be difficult to get The rest are obtainable from many seed shops, and can even be replaced by other related species[2] The *Bandeiraea* lectin is blood group B specific—it can be used with B erythrocytes only , and *Cytisus* lectin is O(H) specific—it should be used with O cells The other lectins can be used with red cells of any blood group

The ability of lectins to differentiate between α- and β-glycosides supports J Lederberg's (personal communication) suggestion that there is some connexion between them and plant glycosidases Lectins are not, however, likely to be true glucosidases because (*a*) they are present in ungerminated seeds and their amount does not increase appreciably after germination[7], (*b*) there is no correlation in occurrence between lectins and glycosidases in plant species[8], and (*c*) several purified lectin preparations have been found not to hydrolyse the disaccharides which inhibit agglutination[8]

The monosaccharide specificity of lectins seems to be less definite than that of glycosidases, though glycosidases are not strictly specific , the members of a certain homomorphous sugar series (sugars with an identical pyranose or furanose ring) behave more or less alike as substrates of glycosidases[9], but many lectins are inhibited by members of two homomorphous series These series can differ with regard to the substituents of carbon atom 2 Thus *Pisum* lectin is inhibited by D-glucose and D-mannose, *Bandeiraea* lectin by D-galactose, D-fucose, L-arabinose and D-talose (see above), and *Lotus tetragonolobus* lectin by L-galactose, L-fucose, D-arabinose and 6-deoxy-L-talose[4] The substituents in carbon atoms 3 and 4 seem to be of the greatest importance to the capacity of monosaccharides to inhibit lectins, a view which was expressed six years ago by Morgan and Watkins[4] with regard to *Lotus tetragonolobus* lectin

I wish to thank Mr E R Vaughan, curator, Botanical Garden, University College of Ghana, who kindly sent me several samples of *Bandeiraea simplicifolia* seeds

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[1] Krupe, M , "Blutgruppenspezifische pflanzliche Eiweisskorper (Phytagglutinine)" (Ferdinand Enke Verlag, Stuttgart, 1956)

[2] Makela, O , *Ann Med Exp Biol Fenn* , 35, Supp 11 (1957)

[3] Boyd, W C , and Shapleigh, E , *Science*, 119, 419 (1954)

[4] Morgan, W T J , and Watkins, W M , *Brit J Exp Path* , 34, 94 (1953)

[5] Kabat, E A , and Leskowitz, S , *J Amer Chem Soc* , 77, 5159 (1955)

[6] Mākelā, O , Mākela, P , and Lehtovaara, R , *Ann Med Exp Biol Fenn* , (in the press)

[7] Mākelā, O , and Lehtovaara, R (unpublished work)

[8] Ensgraber, A , *Ber Deut Bot Ges* , 71, 349 (1958)

[9] "The Carbohydrates", edit by Pigman, W , 44 (Academic Press, New York, 1957)

Reactivity and Interrelationship of Intermediates in the Hydrolysis of *p*-Nitrophenyl Acetate Catalysed by Chymotrypsin

Kinetic studies by Gutfreund and Sturtevant[1] suggest that *p*-nitrophenyl acetate reacts with chymotrypsin rapidly at a *p*H greater than 6 5 to form monoacetyl chymotrypsin (*AC*–I) and that *AC*–I is then deacylated slowly The kinetic observations are consistent with the esterification of a single serine hydroxyl of the enzyme[2] In contrast, spectroscopic studies[3] of the deacylation of monoacetyl chymotrypsin formed at *p*H 5 0 and isolated according to the procedure of Balls and Wood[4], (*AC*–*A*), show that when *AC*–*A* is brought to *p*H 9 0, a rapid increase in absorption at 245 mμ occurs which is followed by slow decay of the absorption peak Since both the absorption peak and its rate of decay appeared characteristic for N-acetyl imidazole, Dixon and Neurath[3] suggested that the deacylation of monoacetyl chymotrypsin proceeds by a rapid intramolecular shift of the acetyl group from a serine oxygen to an imidazole nitrogen of the enzyme (*AC*–II), and that the rate-limiting step of the enzymatic reaction is the base-catalysed hydrolysis of N-acetyl imidazole Recently, however, we have observed[5] that *AC*–I and *AC*–*A* are deacylated at different rates as measured by the liberation of *p*-nitrophenol from *p*-nitrophenyl acetate catalysed by *AC*–I and *AC*–*A*, and that *AC*–I is converted to *AC*–*A* under the conditions used in the isolation procedure[4]

The result of investigations reported below further delineate the differences between *AC*–*A* and *AC*–I, and suggest an interrelationship between *AC*–*A*, *AC*–I and *AC*–II as well as a structure for *AC*–*A* The experiments illustrated in Fig 1 indicate that *AC*–*A* (salt-free α-chymotrypsin, recrystallized three times , gift of the Sigma Chemical Co , St Louis, Missouri) cannot be deacylated via a single intermediate which decomposes with a single rate-constant identical with the rate of decay ($1\ 7 \times 10^{-3}$ sec^{-1})[3] of the 245-mμ absorption peak Curve 1 represents α-chymotrypsin pre-acetylated for 10 min at *p*H 5 0 with 100 equivalents of *p*-nitrophenyl acetate and mixed at zero time with buffer such that the final *p*H was 8 0 Zero-order steady-state liberation of *p*-nitrophenol is observed within 15 sec The rate of deacylation (k_3) of this enzyme (*AC*–I) calculated from the observed rate of liberation of *p*-nitrophenol is $1\ 6 \times 10^{-2}$ sec^{-1} at 15 6° C Curve 2 represents an experiment in which *AC*–*A* was mixed at zero time with *p*-nitrophenyl acetate at *p*H 8 0 The rate of liberation of *p*-nitrophenol during the first 30 sec is only about 70 per cent of the rate observed in curve 1 (*AC*–I), and essentially the same as *AC*–I after 300 sec The deviation from zero-order kinetics observed during the first 300 sec of the reaction of *AC*–*A* with *p*-nitrophenyl acetate is interpreted as indicative of the rates of reactions involved in the conversion of *AC*–*A* to *AC*–I These reactions are presumably the deacylation of *AC*–*A* and its reacylation at *p*H 8 0 to form *AC*–I However, the rate of conversion of *AC*–*A* to *AC*–I is incompatible with the complete deacylation of *AC*–*A* via the N-acetyl imidazole intermediate (*AC*–II), as can be seen

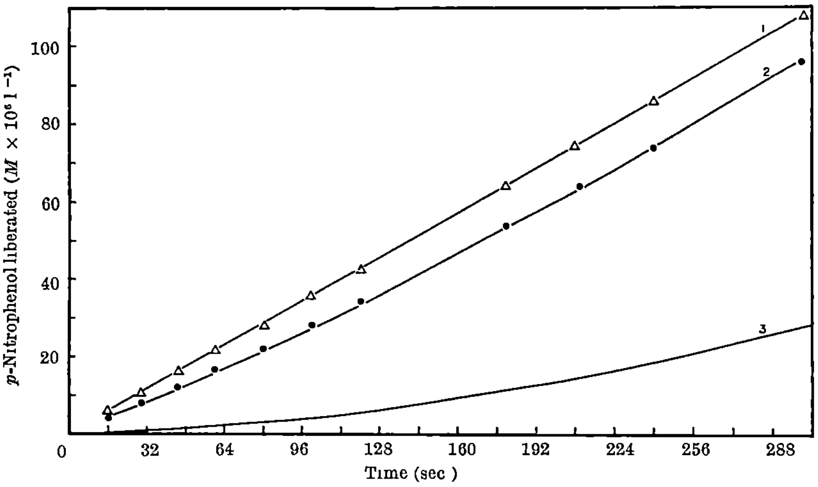
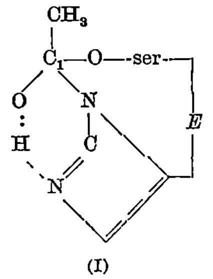


Fig 1 The liberation of *p*-nitrophenol in the catalytic hydrolysis of *p*-nitrophenyl acetate by α-chymotrypsin and monoacetyl-α-chymotrypsin preparations at 15 6° C in *tris*-(hydroxymethyl)-aminomethane–maleate buffer, *p*H 8 0 Total ionic strength 0 12 *M* , $[E]_0 = 2\ 1 \times 10^{-5}\ M$ $[S]_0 = 1\ 7 \times 10^{-3}\ M$ Curve 1, chymotrypsin preacetylated for 10 min with 100 equivalents of *p*-nitrophenyl acetate at *p*H 5 0 and 15 6° C and then mixed with buffer at zero time to bring the *p*H to 8 0 , curve 2, isolated monoacetyl-α-chymotrypsin (ref 4) (*AC*-*A*) , curve 3, a calculated curve for the catalysis of *p*-nitrophenyl acetate by a monoacetyl enzyme which is deacylated with a rate of $1\ 7 \times 10^{-3}$ sec^{-1}

from curve 3 Curve 3 was calculated for a monoacetyl enzyme which is deacylated at a rate characteristic for N-acetyl imidazole ($k = 1\ 7 \times 10^{-3}$ sec $^{-1}$ at *p*H 8 0) Since curves 2 and 3 are not identical one must assume from the spectroscopic studies that the deacylation reaction of *AC–A* can proceed via *AC*–II only partially if at all The rate between the first 15 and 30 sec of reaction in curve 2 is about 70 per cent of the final rate, in curve 3 only about 2 per cent of the final rate It appears, therefore, that only about 30 per cent of *AC–A* can be deacylated via *AC*–II This is consistent with the observation that the absorption at 245 mμ accompanying the deacylation of *AC–A* corresponds to only about 0 4 mole of N-acetyl-imidazole per mole of acetyl-enzyme

The kinetic results appear consistent with two alternatives *AC–A* is either an equilibrium mixture of 70 per cent *AC*–I and 30 per cent of a form of monoacetyl-enzyme which is deacylated via *AC*–II or *AC–A* is a single intermediate which under the conditions used for hydrolysis of *p*-nitrophenyl acetate gives rise to the two separate intermediates, *AC*–I and *AC*–II

To test which of these alternatives is correct, *AC*–I and *AC–A* were allowed to react with hydroxylamine[4] at *p*H 5 5 When the reaction was carried out in water both *AC*–I and *AC–A* reacted to form approximately 1 mole of hydroxamate per mole of enzyme After both preparations were denatured for 2 min in 8 *M* urea at *p*H 5 5 and 23° C the acetyl group of *AC*–I was completely unreactive toward hydroxylamine while that of *AC–A* was completely reactive Since all the acetyl groups of *AC–A* were capable of forming an hydroxamate under conditions which abolish the activity of *AC*–I, then it follows that none of the acetyl groups in *AC–A* are present in the same form as they are in *AC*–I The activity of *AC–A* toward hydroxylamine can be destroyed by denaturing for 10 min at *p*H 5 5 and 23° C or for 2 min at *p*H 3 0 and 23° C These facts are taken into account in proposing the structure for the active site of *AC–A*



(I)

The active site of *AC–A* would be expected to react with hydroxylamine at *p*H 5 5 The results shown in Fig 2 indicate that both *AC*–I and *AC–A* are denatured at the same rate by 8 *M* urea as judged by optical rotation studies Since the active site of *AC–A* is stabilized, not only by the total configuration of the molecule but also by a covalent and a hydrogen bond, it would be more resistant to treatment with urea Removal of the hydrogen bond by urea forms an anionic intermediate which, at *p*H 5 5, leads to the formation of the *O*-acetyl derivative (*AC*–I), which is unreactive toward hydroxylamine in urea solution At *p*H 3 0, the rate of denaturation is faster than at *p*H 5 5 as shown in Fig 2, explaining why the reactivity of *AC–A* toward hydroxylamine is abolished after 2 min in 8 *M* urea at *p*H 3 0 Under basic conditions, such as those used for the kinetic experiments, *AC–A* would be expected to form both the *O*- and the *N*-acetyl derivatives *AC*–I and *AC*–II, by nucleophilic attack at C$_1$

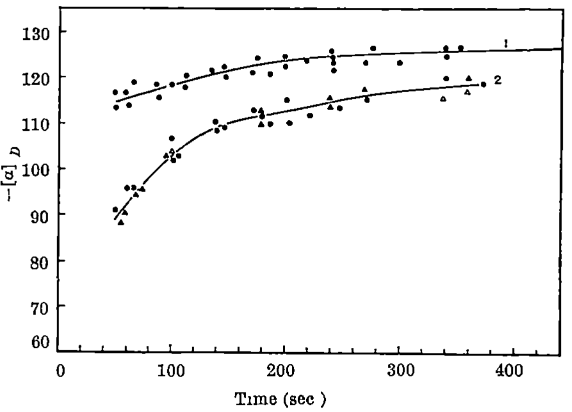


Fig 2 Change with time of the specific rotation of α-chymotrypsin (*CT*) and isolated monoacetyl-α-chymotrypsin (ref 4) (*AC-A* △-△) in 8 *M* urea at 23° C in 0 05 *M* *tris*-(hydroxymethyl)-aminomethane–maleate buffer at *p*H 5 5 (curve 2), and in 0 05 *M* sodium citrate buffer at *p*H 3 0 (curve 1) Optical rotation was measured in a Rudolph photoelectric spectro-polarimeter

The proposed active site of *AC–A* explains the spectroscopic and kinetic results as well as the reactivity toward hydroxylamine

AC–I is kinetically identical to the normal acetyl-enzyme at *p*H 7 0–9 0 Since no significant change in absorption at 245 mμ accompanies the hydrolysis of *AC*–I[5b], there is no evidence for *N*-acetyl-imidazole as intermediate in the normal catalytic reaction

This investigation was supported by grants from the U S Public Health Service and the National Science Foundation We are indebted to Dr Lyman C Craig, Rockefeller Institute, New York City, for the use of the Rudolph photoelectric spectro-polarimeter

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[1] Gutfreund, H , and Sturtevant, J M , *Proc U S Nat Acad Sci* , 42, 719 (1956)
[2] Cunningham, L W , *Science*, 125, 1145 (1957)
[3] Dixon, G H , and Neurath, H , *J Amer Chem Soc* , 79, 4558 (1957).
[4] Balls, A K , and Wood, H N , *J Biol Chem* , 219, 245 (1956)
[5] (*a*) Hess, G P , and Marini, M A , Abstracts, Fourth Internat Congr Biochemistry, 42 (Vienna, 1958) (*b*) Marini, M A , and Hess, G P , *J Amer Chem Soc* , 81, 2594 (1959)

Effect of Purine and Pyrimidine Analogues on Reversion of a Tryptophan-requiring Strain of *Escherichia coli*

WE suggested recently that nucleic acid precursors, altered *in vivo* by ultra-violet light, are involved as chemical intermediates in the induction of mutation[1] We have since reported that, in the absence of an adequate source of nitrogen, an immediate and rapid decline in the frequency of mutations induced by ultra-violet light occurs ('mutation frequency decline')[2] We demonstrated that the prevention of this decline depends on the availability immediately following exposure to radiation of a supply of amino-acids, and suggested that the amino-acids are involved in a process of temporary 'stabilization' of the 'potential mutation' (the modified purine or pyrimidine) in the cell prior to its effect in the induction of mutation ('mutation stabilization')[2]. The potential mutation is ultimately 'fixed' into the cell and is no longer subject to those conditions which previously resulted in decline in mutation frequency ('mutation fixation')[2]. Recently we have reported that the progression of 'mutation fixation' is closely correlated with the synthesis of ribonucleic acid in the culture, and suggested that the initial mutagenic event involves the incorporation of the modified nucleic acid precursor into ribonucleic acid[3]. We wish to report here experiments which determine the effect of certain purine and pyrimidine analogues on reversion induced by ultra-violet light in an auxotrophic strain of *Escherichia coli*.

The mutations studied result in reversion to the prototrophic state of *E. coli* strain *WP2* (tryptophan-requiring strain of Witkin)[2]. The basic procedure followed for culture growth, synchronization, radiation exposure, culture treatment, plating and mutation assay have already been described[1,2]. The procedures used for the determination of nucleic acid and protein have also been described[3].

30 purine or pyrimidine analogues were tested by addition (5 mgm./100 ml.) to incubating cultures immediately following exposure to radiation. The substances tested were 5-bromouracil, thiouracil, 5-methylorotic acid, 5-thioguanine, 8-aza xanthine, 6-aza uracil, caffeine, 5-nitrouracil, 6-aza thymine, 8-aza guanine, 8-aza hypoxanthine, 8-aza adenine, 6-methylthiouracil, 5-aminouracil, 5,6 dichloro-1-(β-D-ribofuranosyl) benzimidazole, 5-bromodeoxyuridine, 5-hydroxyuridine, 5-methylthiouracil, 8-aza xanthine, uramil, diazouracil, 6-mercaptopurine, dithiouracil, 5-nitrouracil, 2-amino-4-methyl pyrimidine and 5-bromouridine. The effect of each on mutation response was determined by plating the cells on the mutation assay agar after 60 or 80 min. incubation with the analogue. Of these analogues, 6-mercaptopurine, 5-hydroxyuridine and 6-aza uracil were found to have a marked effect on the mutation frequency response while 6-thioguanine and 5-nitrouracil lowered the mutation response slightly. Preliminary studies with 5-hydroxyuridine have been reported elsewhere[3].

The decline in mutation frequency promoted by 5-hydroxyuridine is initiated after a lag of some 20 min. and is complete after incubation for 60 min. (Table 1). The initiation of the decline in mutation frequency in the presence of 5-hydroxyuridine is correlated with the initiation of synthesis of ribonucleic acid and is complete at about the time the relative amount of ribonucleic acid has doubled. Protein synthesis begins only after a considerable degree of decline in mutation frequency has occurred. Furthermore, synthesis of deoxyribonucleic acid is initiated after the decline promoted by 5-hydroxyuridine is complete. Thus the decline in mutation frequency in the presence of this analogue can be correlated with the synthesis of ribonucleic acid in the presence of the analogue. A plausible hypothesis to account for this fact is that the analogue is incorporated into ribonucleic acid, thus producing 'non-functional' ribonucleic acid and using up the mutagenic substrate. Preliminary studies indicate that 6-mercaptopurine may exert its effect through a similar mechanism.

Table 1. THE EFFECT OF 5-HYDROXYURIDINE ON MACROMOLECULAR SYNTHESIS AND THE YIELD OF ULTRA-VIOLET-INDUCED PROTOTROPHS FROM *Escherichia coli* STRAIN *WP2*

Post-irradiation incubation time† (min.)	5-Hydroxyuridine, 5 mgm./100 ml.*			
	Prototrophs per 10^8 survivors	Relative concentration		
		RNA	Protein	DNA
0	5,260	1.0	1.0	1.0
20	5,328	1.0	1.0	1.0
30	4,104	1.2	1.0	1.0
40	3,060	1.4	1.0	1.0
60	1,180	1.9	1.5	1.0
80	932	2.4	1.8	1.3

RNA, Ribonucleic acid; DNA, deoxyribonucleic acid.

* Incubation with 5-hydroxyuridine had no effect on survival. The incubation medium was minimal medium (ref. 1) plus casein hydrolysate, 2 mgm./ml. and DL-tryptophan, 0.2 mgm./ml. Ultra-violet exposure was 960 ergs/mm.^{2}

† Incubation prior to plating on to the mutation assay agar (see Doudney and Haas, ref. 3).

Table 2. COMPARISON OF THE EFFECTS OF 6-AZA URACIL AND CHLORAMPHENICOL ON THE YIELD OF ULTRA-VIOLET INDUCED PROTOTROPHS FROM *Escherichia coli* STRAIN *WP2*

Post-irradiation incubation time† (min.)	Chloramphenicol (20 μgm./ml.)	6-aza uracil (5 mgm./100 ml.)*	
	Prototrophs per 10^8 survivors	Prototrophs per 10^8 survivors	Relative ribonucleic acid concentration
0	5,084	5,084	1.0
10	2,480	2,682	1.0
20	1,628	1,850	1.0
30	852	950	1.0
60	820	990	1.1

* Incubation with 6-aza uracil had no effect on survival. The incubation medium was minimal medium (ref. 1) plus casein hydrolysate, 2 mgm./ml., and DL-tryptophan, 0.2 mgm./ml. Ultra-violet exposure was 960 ergs/mm.^{2}

† Incubation prior to plating on to the mutation assay agar (see Doudney and Haas, ref. 3).

We have demonstrated a rapid decline in mutation frequency following addition of chloramphenicol to the culture which is complete to a basal level within 20 min.[3]. Table 2 demonstrates that the decline promoted by 6-aza uracil (unlike that promoted by 5-hydroxyuridine) is closely correlated with the decline promoted by chloramphenicol. 6-Aza uracil, like chloramphenicol, blocks protein synthesis. However, unlike chloramphenicol, the analogue presumably blocks protein synthesis through direct blockage of the synthesis of ribonucleic acid. Uridine will reserve the blockage to ribonucleic acid and protein synthesis and will also prevent the decline in mutation frequency promoted by the compound. We thus assume that 6-aza uracil has the capacity to promote 'mutation frequency decline' as does chloramphenicol by interfering with 'mutation stabilization'.

These studies were supported in part by research grant *C*-3323 from the U.S. National Institutes of Health and by U.S. Atomic Energy Commission Contract *AT*-(40-1)-2139.

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[1] Haas, F. L., and Doudney, C. O., *Proc. U.S. Nat. Acad. Sci.*, **45**, 871 (1957).

[2] Doudney, C. O., and Haas, F. L., *Proc. U.S. Nat. Acad. Sci.*, **44**, 390 (1958).

[3] Doudney, C. O., and Haas, F. L., *J. Mol. Biol.* (in the press).

Activation of Staphylococcal-free Coagulase by Purified Human Prothrombin

Free coagulase[1] is an extracellular protein produced by pathogenic staphylococci[2], which reacts with coagulase activator[3], present in the plasma of certain animal species, to yield an active material capable of clotting any fibrinogen[1] The active material has been called activated coagulase[4] and has been shown recently, by a study of the kinetics of the reaction between purified free coagulase[5] and an impure preparation of coagulase activator, to be produced during the enzymic degradation of the former by the latter This work, however, shed no light on the vexed problem of the nature of coagulase activator[3,6–9], owing to the inhomogeneity of the coagulase activator preparation employed

Through the kindness of Dr F Duckert of the Medizinische Universitatsklinik, Zurich, we have been able to repeat some of these experiments, using, as the source of coagulase activator, a highly purified sample of human prothrombin prepared by chromatography on barium sulphate and 'Hyflosupercel' by a slight modification of the method used by Duckert, Koller and Matter[10] This material contained about 1,000 units of prothrombin and 160 units of coagulase activator per mgm protein, and was thus enriched between 600 and 700 times (Dr Duckert, private communication)

Solutions of prothrombin in phosphate buffer (0 07 *M* disodium hydrogen phosphate–potassium dihydrogen phosphate, *p*H 6 8) were incubated at 37° C with various concentrations of free coagulase and activated coagulase was assayed in the mixtures as already described[4] The results, which are summarized in Table 1, are essentially similar to those obtained previously[4] and demonstrate the instability of activated coagulase under these conditions The concentration of activated coagulase produced and the length of time before its exhaustion are directly dependent upon the initial concentration of free coagulase in the mixture These facts, together with the finding that the exhausted mixtures still contain coagulase activator but no free coagulase, confirm that free coagulase is enzymically degraded by coagulase activator

Table 1 Formation and Destruction of Activated Coagulase in Mixtures containing a Constant Amount of Purified Human Prothrombin and Various Amounts of Free Coagulase

Values given are for the concentration of activated coagulase (units/ml)

Incubation time of mixture at 37° C (hr)	Concentration of coagulase (units/ml) added to an equal volume of purified human prothrombin (250 μgm /ml)			
	25	10	5	2
0	3 3	1 9	1 2	0 5
1	4 3	2 8	1 4	0 6
2	4 0	2 8	1 4	0 6
3	4 0	2 4	1 4	0 5
4	3 8	2 4	0 9	0 3
5	4 3	1 5	0 8	0 25
6	4 0	1 4	0 6	0 23
8	3 0	0 8	0 5	0 17
22	1 5	0 9	0 34	0 08

After incubation for 22 hr the mixtures were divided into three portions and to (*a*) was added an equal volume of prothrombin 190 μgm /ml , to (*b*) an equal volume of coagulase 25 units/ml and to (*c*) an equal volume of buffer They were then incubated for 10 min and the activated coagulase content measured as before

a	0 5	0 12	<0 1	<0 1
b	3 1	2 7	2 0	2 0
c	0 5	0 13	<0 1	<0 1

In view of the highly purified nature of the human prothrombin used as a source of coagulase activator, it seems likely that the two are identical This suggestion is supported by the observation that the ratio of prothrombin to coagulase activator in normal human plasma is identical with that in the present highly purified preparation of prothrombin

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[1] Duthie, E S , *J Gen Microbiol* , **10**, 427 (1954)
[2] Much, H , *Biochem Z* , **14**, 143 (1908)
[3] Smith, W , and Hale, J H , *Brit J Exp Path* , **25**, 101 (1944)
[4] Haughton, G , and Duthie, E S , *Biochem J* , **71**, 348 (1959)
[5] Duthie, E S , and Haughton, G , *Biochem J* , **70**, 125 (1958)
[6] Duthie, E S , and Lorenz, L L , *J Gen Microbiol* , **6**, 95 (1952)
[7] Tager, M , *Yale J Biol Med* , **20**, 369 (1948)
[8] Tager, M , *J Exp Med* , **104**, 675 (1956)
[9] Haughton, G , Ph D thesis, University of Southampton (1958)
[10] Duckert, F , Koller, F , and Matter, M , *Proc Soc Exp Biol Med* , **82**, 259 (1953)

CHEMISTRY

Separation of Polyvinyl Chloride and Polyvinyl Acetate by Chromatographic Methods

The material used in this work was known to contain at least two co-polymers A method of separation was sought which would not require a complex chemical procedure The separation of high polymers by chromatographic means was carried out by Claesson[1], while separations on columns packed with carbon black were attempted by Landler[2]

It was found that absorption decreased with increased molecular weight A column of activated charcoal was packed and saturated with methyl *iso*-butyl ketone The mixture containing the two co-polymers in this solvent was added to the top of the column and washed with the solvent After a few minutes, the elutant was giving a positive test for chloride After 1 hr washing the fractions began to give positive acetate results

In order to attempt some form of confirmation, a method of separation was devised by paper chromatography

The mixed co-polymers in solution were spotted on to a strip of Whatman's No 4 filter paper and air-dried This strip was then allowed to run at room temperature for 45 min , using once again methyl *iso*-butyl ketone as a solvent The strip was then air-dried and sprayed with a solution of one part B D H Universal indicator and one part distilled water The whole strip was then washed in distilled water and dried The acetate spot remained stationary, while the chloride moved with the solvent front R_F values were for chloride 0 985 and 0 0 for the acetate Both spots were eluted, yielding positive tests for acetate and chloride, respectively

To determine the accuracy of the separation, two pure polymers of acetate and chloride were mixed in the solvent These were then spotted on to a No 4 filter paper and run as a control Identical results were obtained as with the mixed co-polymers

This method is not suggested as an analytical procedure but as a rapid means of separating mixed polymers

Further details of this work will be published elsewhere.

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[1] Claesson, I., and Claesson, S., *Arkiv Kemi, Min. Geol.*, 19,A, No. 5 (1944). Claesson, S., *Dis. Farad. Soc.*, 7, 321 (1949).

[2] Landler, *C.R. Acad. Sci., Paris*, 225, 234 (1947).

A New Method for working up Processing Mixtures containing Anhydrous Aluminium Chloride

ON working up the mixture in order to isolate the products of reactions catalysed by anhydrous aluminium chloride, the first step is usually decomposition with an ice-acid mixture[1]. However, difficulties are often encountered in the separation of the aqueous phase containing the aluminium salts, due to the formation of stable emulsions. This makes the repeated washing of the organic phase necessary to ensure complete extraction of the aluminium salts, a rather tedious operation.

In our experiments we found that a solution of sodium fluoride could be used with advantage at this stage, and also to eliminate interference during later stages. The favourable effect is due to the formation of the complex Na_3AlF_6 which is soluble in water. The advantages of the method may be summarized as follows.

1. The aqueous solution, when it contains sodium aluminium fluoride, is readily and quickly separable from the organic phase, in our experiments, nitrobenzene.

2. When the second step of working up the reaction mixture is steam distillation of an alkaline solution, no separation of the aqueous phase is necessary. Further, as the aqueous phase is already alkaline, no addition of alkali is required to secure the alkaline reaction of the medium.

3. When a neutral solution is wanted during processing, a slightly acidified solution of sodium fluoride can be used. The exact amount of hydrochloric acid necessary can be determined by blank tests on a solution of anhydrous aluminium chloride at the same concentration as the reaction mixture. These blanks are of great importance as the quantity of acid required depends on the quality of the sodium fluoride.

4. Since the method facilitates the working up and analysis of very small quantities, it is particularly suitable for micropreparation and kinetic studies. Although stoichiometrically 6 moles of sodium fluoride are required for each mole of aluminium chloride, we find it best to use at least 7 moles of the reagent.

As an example, part of an unpublished kinetic study will be given here, where a quantitative determination of the ketone was carried out on the mixture obtained by the Fries rearrangement of thymyl acetate in nitrobenzene, in the presence of aluminium chloride.

Preparation of thymyl-methyl ketone. 2·4031 gm. (12·4 m.moles) of 99·14 per cent thymyl acetate was treated with a solution of 4·17 gm. (31·3 m.moles) of anhydrous aluminium chloride (B.D.H.) in nitrobenzene, and the mixture was made up to 20 ml. with nitrobenzene. The mixture was allowed to stand for 5 hr. in a thermostat of 40° C., and then an aliquot of 2 ml. was transferred by pipette into an equal volume of ethanol. This mixture was refluxed for 30 min. with 30 ml. of a solution of sodium fluoride (containing 35 gm. sodium fluoride), 3 ml. of 1 *N* sodium hydroxide and 24 ml. of ethanol. After cooling, the solution was made up at room temperature to 100 ml. with water and allowed to stand overnight in a glass cylinder, 2·5 cm. in diameter, when nitrobenzene separated. A portion of 50 ml. was withdrawn from the clear supernatant with a pipette, treated with 3 ml. of 1 *N* hydrochloric acid and distilled until the temperature of vapour reached 98° C. (approximately 5 min.). The residue was allowed to stand for 2 hr. in an ice box, then the precipitated crystals were filtered through a glass filter, dried at 110° C. for an hour and weighed together with the filter. Thymyl-methyl ketone was then separated from inorganic contaminants by treating the filter with 3 × 5 ml. of hot ethanol. After drying the filter for 20 min. at 110° C., it was again weighed. The difference was 0·0881 gm. The almost white, crystalline product obtained by evaporating the ethanolic solution had a melting point of 122·5–125° C. For $C_{12}H_{16}O_2$, molecular weight 192·25: calculated (per cent): C, 74·97; H, 8·39; found (per cent): C, 74·95; H, 8·07.

The ketone obtained by the classical Rosenmund method[2] was nearly black, m.p. 115–122° C.

The correction for the solubility of the ketone gives a gross yield of 0·092 gm.; thus by the Fries rearrangement a yield of 94·6 per cent was obtained. With suitable modifications the quantity of unconverted ester can also be determined by titration[3].

We wish to thank the Hungarian Academy of Sciences for a grant and the Microanalytical Laboratory of the Institute of Organic Chemistry of the University of Szeged for carrying out the microanalyses.

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[1] Thomas, C. A., "Anhydrous Aluminium Chloride in Organic Chemistry" (Reinhold, New York, 1941).

[2] Rosenmund, K. W., and Schnurr, W., *Ann. Chem.*, 460, 56 (1928).

[3] Furka, A., and Szell, T., *Acta Phys. Chem. Szeged* (in the press).

PHYSICAL SCIENCES

Calculation of a 'Cosmic Ray Age' for the Iron Meteorite 'Carbo'

THE potassium of the iron meteorite 'Carbo', compared with ordinary potassium, is substantially enriched in the isotopes potassium-40 and -41, as shown in the recent isotopic analysis by Voshage and Hintenberger[1]. At least 15 per cent of these isotopes in their sample of 'Carbo' appear to have been produced through the action of cosmic rays. Stoenner and Zähringer[2] found that the concentration of potassium may vary considerably within an iron meteorite. Their analyses were based on the detection of potassium-41 and the assumption that the potassium had the same isotopic composition as terrestrial potassium. If, however, their value of 0·031 p.p.m.

of potassium from one sample is typical of 'Carbo' and is corrected to 0.012 p.p.m. in order to fit the new isotopic analysis, the potassium produced by spallation is at least 4.6×10^{-11} mole/gm. The total ion beam in the Voshage and Hintenberger analysis indicated that the concentration of potassium-40 alone is even greater than 1.8×10^{-12} mole/gm. The amount of potassium produced by spallation is probably about 10^{-11} mole/gm. This figure is quite compatible with that of 1.1×10^{-10} mole/gm. for the helium-3 content[2] because the cross-section for the formation of potassium, including the contribution from argon-39 and calcium-41, seems to be[3] about 40 mb., and the measured cross-section for the production of helium-3 (with hydrogen-3) by means of 3 BeV. protons on iron is approximately[4] 340 mb. The neon also formed by spallation has a concentration[5] of 5.8×10^{-12} mole/gm., which is comparable with that indicated for the potassium.

Radioactive species formed by spallation have been used to estimate the production rate of stable isotopes by cosmic rays. Radiation ages have been calculated in this way for meteorites from their helium-3 and argon-38 contents[6]. The combination of stable isotopes of potassium with the relatively long-lived potassium-40 may also be used to calculate a 'cosmic ray age', Δt in the following equation:

$$\frac{1 - e^{-\lambda \Delta t}}{\Delta t} = \frac{\lambda K_m^{40} (\sigma_{39} - R\sigma_{41})}{\sigma_{40}(K_m^{39} - RK_m^{41})}$$

The relative abundances of the potassium isotopes used are $K_m^{39} = 0.795$, $K_m^{40} = 0.048$, and $K_m^{41} = 0.157$, as reported by Voshage and Hintenberger[1] for the meteorite 'Carbo'. The total decay constant, λ, is taken as 0.529×10^{-9} yr.$^{-1}$. R is the ratio of K^{39}/K^{40} in ordinary potassium.

In addition to the usual assumption regarding a constant cosmic ray flux, some knowledge of the cross-sections for the formation of the potassium isotopes is required. The cross-section versus mass curves for argon formed by high-energy protons on iron and copper are well defined experimentally (refs. 3 and 4 and Bieri, R. H., personal communication). The curves are similar and are skewed towards the side of the neutron-rich isotopes. The known isotopes of potassium suggest that the spallation curve of this element is similarly asymmetrical and that the production cross-sections for potassium-40 and -41 are rather large and approximately the same.

Barr[3] has estimated the approximate production cross-sections for the isotopes potassium-39, -40 and -41 for 5.7 BeV. protons on copper. These cross-sections are 5.2, 9.4 and 9.2 mb., respectively. He inferred them from his measurements of the yields of more than fifty radioactive isotopes produced by the spallation of copper. The observed cross-sections for potassium-42 and -43 were 5.4 and 1.1 mb., respectively. Other spallation products such as argon-39 and calcium-41 contribute significantly to the formation of potassium. The cross-sections for the formation of potassium estimated from Barr's work then become $\sigma_{29} = 14.8$, $\sigma_{40} = 9.4$, and $\sigma_{41} = 14.7$ mb.

The radiation age calculated from the preceding values is $0.6_9 \times 10^9$ yr. It is obvious in the above equation that the value for σ_{39} is comparatively insignificant. This figure may be incorrect by a factor of 2 without influencing the value of the right side of the equation by more than 10 per cent. The relative values for σ_{40} and σ_{41} are important. A difference of even 20 per cent in their ratio affects the radiation age by 1×10^9 years. This seems to be approximately the uncertainty in this radiation age of 'Carbo'; but the relative ages of iron meteorites may be determined with much greater precision. For the radiation age from the potassium to be 4.6×10^9 years, or the same as the lead–lead age[7,8] and the rubidium–strontium age[9,10] of stone meteorites, σ_{41} would have to be about one-half the value for σ_{40}. It should be noted that contamination will have a negligible effect on the radiation age as long as the observed abundance of potassium-40 is much greater than the potassium-40 in ordinary potassium.

The cosmic ray age calculated here for 'Carbo' is essentially the same as its estimated cosmic ray helium age of 0.85×10^9 years[11]. The potassium–argon ages of several stone meteorites are also quite similar. The chondrites 'Kunashak' (grey variety) and 'Pervomaiskii Poselok' (grey variety) have ages of 0.70×10^9 and 0.64×10^9 years, respectively[12]. The two shergotites 'Padvarninka' and 'Shergotty' have ages of 1.0×10^9 years[12] and 0.56×10^9 years[13], respectively. It seems that the stone meteorites belong to two groups, one with radiogenic helium ages of 4×10^9 years, the other with ages of about 0.5×10^9 to 1×10^9 years[14]. Helium probably has been lost from the meteorites of the latter group. The potassium–argon ages for the same meteorites clearly indicate some loss of argon[14].

The accuracy of the cosmic ray age calculated from the potassium produced by spallation depends principally upon how well the ratio of the formation cross-sections for potassium-40 and -41 is known and the constancy of the cosmic ray flux. Nevertheless, this age of $0.6_9 \times 10^9$ years agrees remarkably well with independent age determinations for this meteorite and for other meteorites. Evidence is rapidly accumulating for the break-up of solid bodies and for the presumably related heating of at least some of the meteorites between 0.5 to 1.0×10^9 years ago. The comparison of potassium analyses from other iron meteorites may help to answer the question of whether these processes occurred throughout approximately half a thousand million years or during a much shorter interval.

I wish to thank Dr. R. H. Bieri and Dr. J. Geiss of this Institute for many discussions. This study was supported by a grant from the U.S. National Science Foundation.

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[1] Voshage, H., and Hintenberger, H., *Z. Naturf.*, 14,a, 194 (1959).

[2] Stoenner, R. W., and Zähringer, J., *Geochim. et Cosmochim. Acta*, 15, 40 (1958).

[3] Barr, D. W., thesis, University of California, Radiation Laboratory Report 3793 (1957).

[4] Schaeffer, O. A., and Zähringer, H., *Z. Naturf.*, 13,a, 346 (1958).

[5] Wänke, H., and Hintenberger, H., *Z. Naturf.*, 13,a, 895 (1958).

[6] Geiss, J., *Chimia*, 11, 349 (1957).

[7] Patterson, C. C., *Geochim. et Cosmochim. Acta*, 7, 151 (1955).

[8] Marshall, R. R., and Hess, D. C., *J. Chem. Phys.*, 28, 1258 (1958).

[9] Schumacher, E., *Z. Naturf.*, 11,a, 206 (1956).

[10] Webster, R. K., Morgan, J. W., and Smales, A. A., *Trans. Amer. Geophys. Union*, 38, 543 (1957).

[11] Reed, G. W., in Proc. Third Conf. on Nuclear Processes in Geologic Settings, Massachusetts Institute of Technology, 27 (National Academy of Sciences—National Research Council Pub. 572, 1957).

[12] Gerling, E. K., and Levskii, L. K., *Dokl. Akad. Nauk SSSR*, 110, No. 5, 750 (1956).

[13] Geiss, J., and Hess, D. C., *Astrophys. J.*, 127, 224 (1958).

[14] Reed, G. W., and Turkevich, A., *Nature*, 180, 594 (1957).

Refraction of Very High Frequency Radio Signals at Ionospheric Heights

PEOPLE engaged in radio tracking of space vehicles are well aware of the fact that the Earth's atmosphere may cause serious refractive errors in the elevation angle determination It is also generally accepted that refractive errors rapidly decrease with an increase in the elevation angle, and become virtually negligible above 10 or 15 degrees In the case of radio astronomy, this is quite true However, in the case of space-vehicles, which travel in the immediate vicinity of the Earth, this is not the case The refractive errors due to the troposphere rapidly decrease with the elevation angle, while those due to the ionosphere initially increase with the elevation angle, and then gradually fall off This behaviour of ionospheric refraction is a necessary consequence of the spherical geometry The value of the elevation angle at which the maximum ionospheric refractive error occurs lies typically between 100 and 200 milliradians The exact expressions are rather involved, but it can be shown that the value of this angle is roughly proportional to the square root of the height of the layer The maximum value of the ionospheric refractive error is about 10–15 per cent higher than its value for a tangentially departing ray

Fig 1 shows a plot of the elevation angle error δ for realistic models of the ionosphere and troposphere The tropospheric calculations were based on radiosonde data The ionospheric calculations were based on a model of electron density profile which was parabolic below the region of the maximum density and was represented by the hyperbolic secant above the maximum The constants of the hyperbolic secant were adjusted so that the profile and its derivative were continuous everywhere, and the total electron content above the maximum was three times as large as below it This is in accord with experimental data based on Faraday rotation measurements[1] Details of the computational techniques are described elsewhere[2]

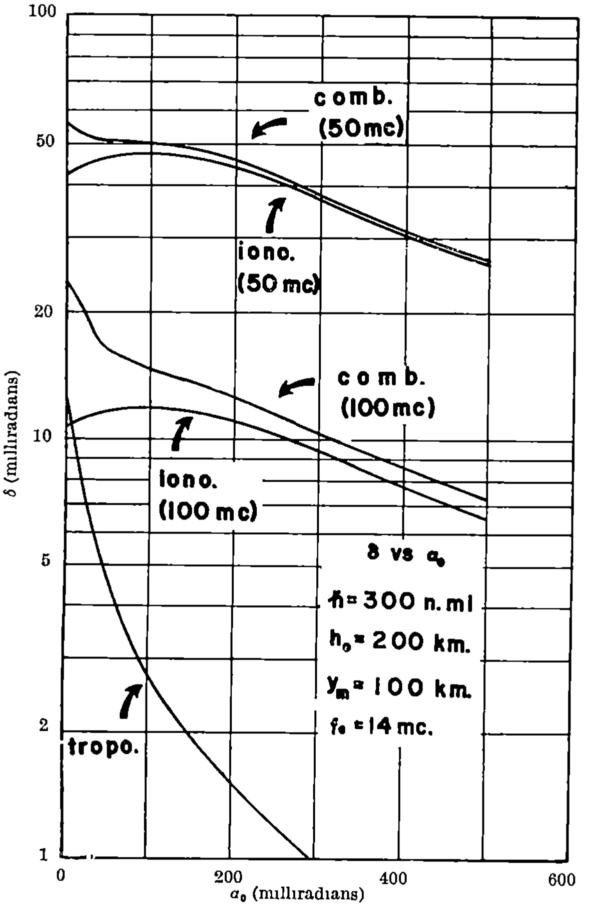

Fig 1

For the purpose of the accompanying illustration, the ionospheric constants were adjusted as follows height of the base 200 km , half thickness 100 km , critical frequency 14 mc , signal frequencies 50 and 100 mc The target height for which the refractive errors were computed was 300 nautical miles

Examination of Fig 1 shows that, at very low angles of elevation, α_0, the tropospheric refraction contributes appreciably to the refractive error while, at higher angles, the ionospheric factors predominate The peculiar behaviour of the ionospheric refraction manifests itself by the presence of the shoulder which is especially prominent at 50 mc , and also by the fact that the refractive error decreases more slowly with the elevation angle than might have been expected from the study of the refraction of radio stars

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[1] Evans, J B , *Proc Phys Soc* , B, 69, 953 (1956)

[2] Weisbrod, S , and Anderson, L J , *Proc Inst Rad Eng* (in the press)

Near Infra-Red System of Nitrogen

IN the course of studying the molecular spectrum of nitrogen under various excitation conditions, Carroll and Sayers[1] discovered a new triplet transition in the near infra-red Only one band was observed as the spectral region of interest was dominated by bands of the first positive system A spectrogram of the new band was given together with measurements of the four strongest heads at 8265 5, 8283 8, 8293 3 and 8310 6 A The structure of the band was obviously complex, and it was suggested by Carroll and Sayers that the transition might be $^3\Pi - {}^3\Sigma$

More recently Kistiakowsky and Warneck[2] have reported bands of nitrogen in the infra-red, and these observations have been extended by LeBlanc, Tanaka and Jursa[3], who studied the emission from afterglows in argon–nitrogen mixtures at low temperature They also made a preliminary vibrational analysis and showed that the lower state was most probably $B\ ^3\ _g$

There is no doubt that the new system is the same transition as that reported by Carroll and Sayers This is proved by (*a*) the close similarity in structure between the 8265 5 A band on Carroll and Sayers's spectrogram and the bands in the spectrogram given by LeBlanc, Tanaka and Jursa , and (*b*) the agreement between the measurements of corresponding heads in the 8265 5 A band and the $(n + 1) - 1$ band of LeBlanc, Tanaka and Jursa

As the new system is of both theoretical[4] and astrophysical[5] interest the 8265 5 A band has recently been investigated under large dispersion It was photographed in the second order of the 21-ft grating in the Physics Department of University College, Dublin, and despite the weakness of the band and the presence of the first positive system, a rotational analysis proved possible Three components were found, each consisting of a fairly strong *P*, *Q* and *R* branch together with a number of weaker satellite branches A detailed examination of the results shows unambiguously that the upper state is of species $^3\Sigma^-_u$ A preliminary value of B_{n+1} determined from the *Q* branches alone gives 1 38_0 cm $^{-1}$ The analysis also verified beyond doubt that the lower state of the 8265 5 A band is the level $v = 1$ of $B^3\Pi_g$ This is shown by the excellent agreement between the combination differences derived from the present analysis and those formed from the data on the 1–0 band of the first positive system[6]

The vibrational numbering of the levels in the $^3\Sigma^-_u$ state is not known with certainty at present However, one can say that the $v = 0$ level cannot lie above about 71,700 cm $^{-1}$ and that it very probably lies within a few vibrational quanta of this value Now Mulliken[4], in his theoretical work on nitrogen, has predicted that a $^3\Sigma^-_u$ state, with a *B* value of approximately 1 47 cm $^{-1}$, should occur at about 70,700 cm $^{-1}$ It is seen that the results of the present work are in satisfactory agreement with Mulliken's theoretical predictions

A full account of the above work will be published elsewhere in the near future

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[1] Carroll, P K, and Sayers, N D, *Proc Phys Soc*, A, **66**, 1138 (1953).

[2] Kistiakowsky, G B, and Warneck, P, *J Chem Phys*, **27**, 1417 (1957)

[3] LeBlanc, F, Tanaka, Y, and Jursa, A, *J Chem Phys*, **28**, 979 (1958)

[4] Mulliken, R S, "The Threshold of Space", 169 (Pergamon Press, New York, 1956)

[5] Khvostikov, I A, and Megrelishvili, T G, *Nature*, **183**, 811 (1959)

[6] Carroll, P K, *Proc Roy Irish Acad*, A, **54**, 369 (1952)

Luminous Spots on Electrodes in Insulating Oil Gaps

In 1955 we reported the observation of luminous spots on electrodes in transformer oil[1] The spots were detected by a photographic plate in the oil between the electrodes with application of a c and d c voltage stresses for 2–30 min The oil was usually degassed but not filtered The luminous spots occurred at random on the surface of a plane electrode and were more concentrated at sharp edges One of the electrode systems used was an American Society for Testing Materials oil-breakdown test-cup The threshold average electric stress seemed to be of the order of 50 kV /cm minimum At the time of those experiments it was not known whether these luminous spots were due to discharges in tiny bubbles or to another cause.

Since those preliminary experiments, more refined and efficient techniques have been used in the investigation of these luminous spots, whereby the electrodes are observed face on through a glass window coated with transparent semiconducting tin oxide Microscopic examination has shown that, while bubbles do occur sometimes at high stresses under low hydrostatic pressures, or with fibres present, bubbles are not responsible for the luminous spots observed on electrodes in well-filtered, degassed oil The luminous spots have been shown to occur only at the negative electrode with d c stresses and are therefore attributed to fluorescence of the oil molecules excited by field-emitted electrons from points of high localized electric stress on the electrodes They have been detected by 10-min exposures with Ansco Super Hypan Film (*ASA* 500) in a camera having an *f*2 lens opening at a distance of about 5 in It is believed that these luminous spots are similar to the luminosity reported seen by Darveniza[2] at 600 kV /cm, but detected here at much lower average electric stresses The threshold voltage stress seems to be of the order of 50–250 kV /cm, depending on the degree of polish of the electrodes and filtering of the oil The local electric stress is very likely 10 or more times higher

M Wachtel (Westinghouse Research Laboratories, private communication) and Llewellyn-Jones[3] have reported electron field emission into a vacuum or low-pressure gas at average electric stresses of the same order as used here

The occurrence of luminous spots is not significantly affected by applied hydrostatic pressure from 10 mm mercury to 2 atmospheres They also occur with a c voltages between glass surfaces, indicating that field emission occurs from glass surfaces The luminosity is not affected by an efficient additive, benzil, reported by Basseches and McLean[4] to prevent gassing

It is believed that observation of these luminous spots assists in explaining the statistical effect of electrode area (and volume) on breakdown, particularly in commercial tests, and the dependence of long time a c electric strength on time of voltage application It also suggests the origin of the development of gas (hydrogen) in stressed oils, since the electrons exciting fluorescence (requiring about 3 eV) may also have or gain by acceleration sufficient energy to decompose the hydrocarbon oil molecules (requiring about 4 eV)

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[1] Dakin, T W, and Berg, D, Conference Paper, Winter General Meeting, Amer Inst Elect Eng (Feb 1955)

[2] Darveniza, M, *Nature*, **183**, 743 (1959)

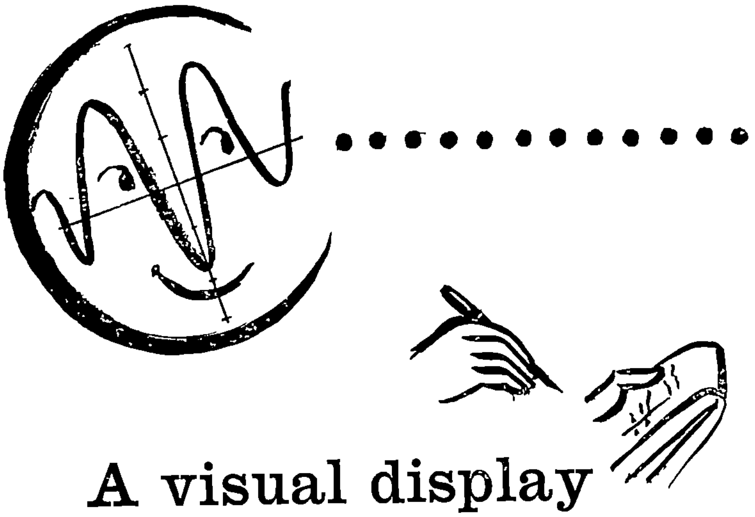
[3] Llewellyn-Jones, F, "Ionization and Breakdown in Gases", 105 (John Wiley and Sons, Inc, New York, 1957)

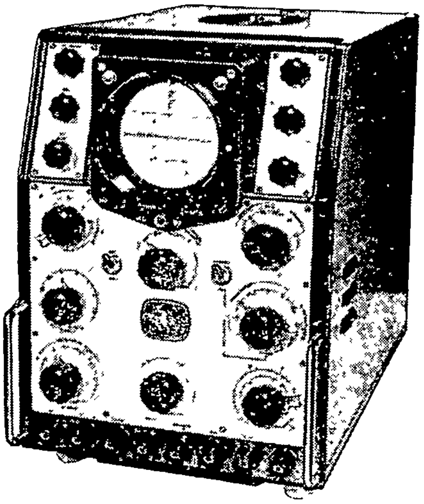
[4] Basseches, H, and McLean, D A, *Indust Eng Chem*, **47**, 1782 (1955)

Compaction of Briquettes

When a powder is compacted by a simple application of pressure, the density and strength of the compact so formed (measured after the pressure has been released) are determined by the pressure used, but ultimately they approach limiting values which are not exceeded by further increasing the pressure The limiting density of the compact falls short of the density of the material of the powder by an appreciable margin, say 4–20 per cent, depending on the material used (Fig 1)

This failure to achieve complete compaction arises in two ways First, as the briquetting pressure is applied it is opposed by forces set up in the powder





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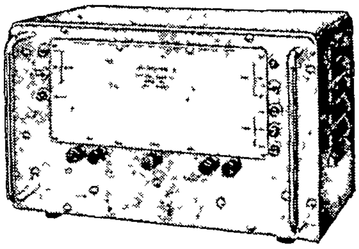

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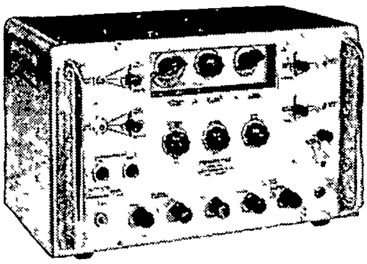

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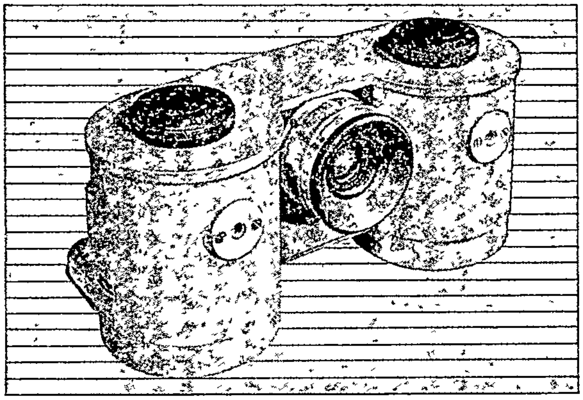

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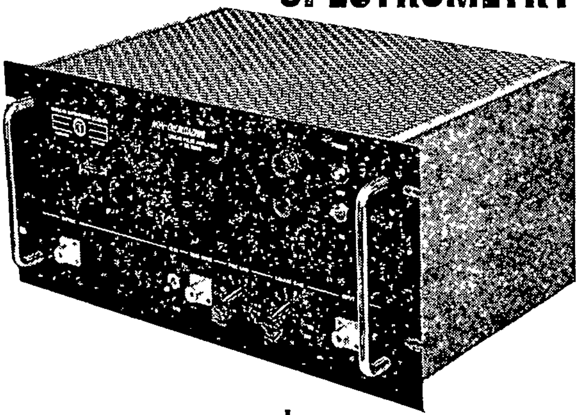

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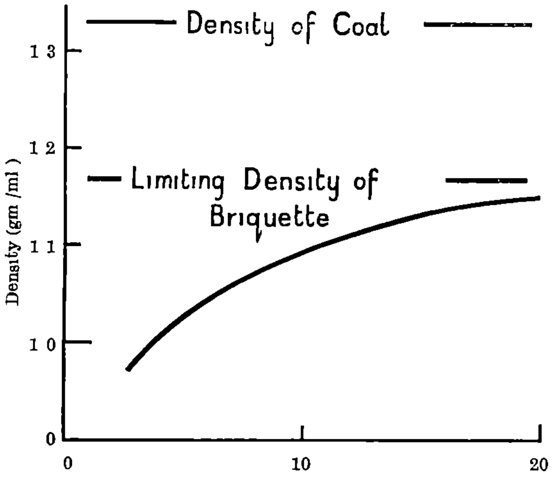
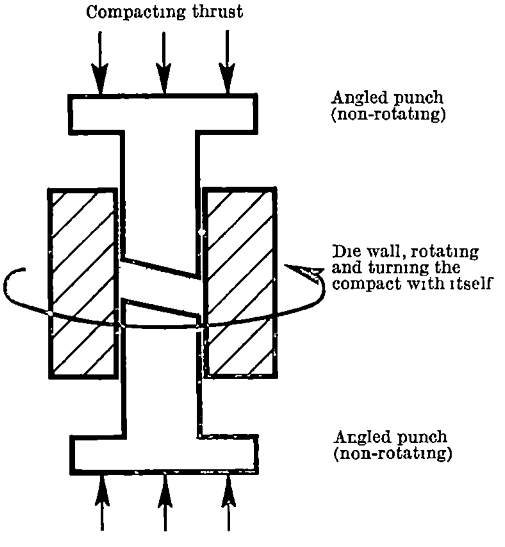


Fig 1 Betteshanger coal relationship between briquetting pressure and density of briquette

and upon the walls of the mould, which resist the movement of the particles and which resist the deformation of individual particles, these forces prevent intimate contact between the particle surfaces Secondly, as the external pressure is removed, the deformed particles recover their shape elastically, in part at least, and the compact expands and the voids within it increase A large elastic recovery is associated with a weak compact

It has been found that if the powder compact, while still under load, is subjected to shear strain, (as for example in a rotary shearbox as sketched in Fig 2) there is a further compaction without any further increase in pressure being required Also, the elastic recovery of the compact when constraints are removed is reduced The compact made in this way is stronger than one made by simple pressing at the same pressure, and may possess greater density and strength than the limiting values obtained by simple pressing Whether the compact is made by simple pressing or by introducing additional shear strain under load, the strengths and densities are still related by the same single curve The gain in strength may be substantial, and with coal powders a five-fold increase has been attained. The full benefit is obtained only if the shear strain is introduced under maximum load (Fig 3)


Compacting thrust
Angled punch (non-rotating)
Die wall, rotating and turning the compact with itself
Angled punch (non-rotating)

Surface of contact between punches and compact are lubricated to allow the compact to rotate within the die wall

Fig 2 Action of a rotary shearbox

The response to the introduction of additional shear strain under load varies with the material In a material such as 'Plasticine', which deforms plastically very readily and which has negligible elastic recovery, the process offers no advantage Natural graphite powder also compacts readily, and reduces to a compact of about 4 per cent porosity by simple pressing , here again there is little advantage in applying extra shear strain, which may do more harm by disrupting the briquette than good by compacting it At the other extreme, anthracite powder, which shows an elastic recovery of 30 per cent while still in the die in which it has been pressed, forms no compact at all, with or without extra shear strain The advantage of the process is found with materials lying between these extremes The coal, the properties of which are illustrated in Fig 3, is an example , the introduction of extra shear strain improves the compaction of the final briquette by about 10 per cent porosity, and the strength by a factor of 3–5

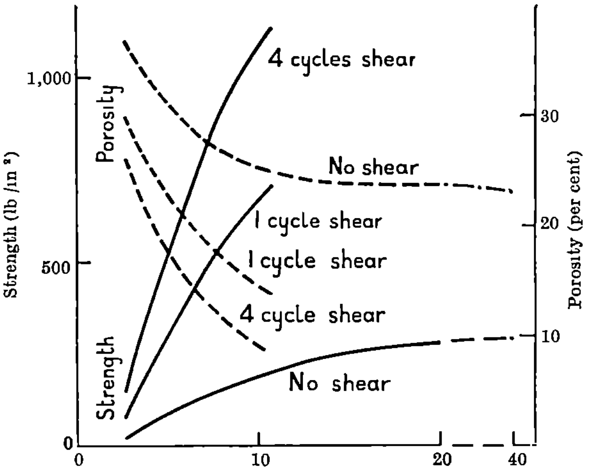


Fig 3 Sherwood coal relationship between briquetting pressure, shear strain, strength and porosity (shear strain introduced in cycles of amplitude 8°)

The adhesion of particles in these non-metallic compacts is not yet fully understood, nor is the action understood whereby shear strain improves the adhesion The fact that a single strength–density relationship applies to all compacts made from a given powder, with or without extra shear, suggests that no new mechanism of adhesion is introduced by shearing

The work described in this paper was carried out as part of the research programme of the Scientific Department of the National Coal Board and is published by permission of the Director-General of Research

H R Gregory
D C Rhys Jones
J W Phillips

National Coal Board,
Coal Research Establishment,
Stoke Orchard,
Cheltenham. May 26

BIOLOGY

Association between Colour of the Iris of the Eye and Reaction to Dental Pain

An association has been found to exist, in Australians of European stock, between the colour of the eyes and the reaction to pain resulting from dental cavity preparation.

At the present stage of this study, examination has been made of 403 consecutive subjects whose teeth were being prepared for filling, the cavities being cut by means of the Borden high-speed air-rotor apparatus. Their ages ranged from three years to more than fifty years.

The pain reaction of each subject was assessed, four classes being used: subjects that showed (*a*) no pain reaction during the preparation of the cavity, (*b*) a slight reaction, (*c*) a marked reaction and (*d*) those whose reaction was so great as to require the injection of a local analgesic. After having recorded the pain reaction of a subject, the colour of the iris was observed, nine categories, ranging from blue to dark brown, being recorded. The pain-reaction classes were given arbitrary values of 0–3, and the colours of the iris, values of 1–9.

The association between these factors is highly significant, but, of course, is considered to be due to their joint association with other factors. The accompanying graph (Fig. 1) of mean values displays the association between pain reaction and colour of iris.

Each point of the graph is based on more than 40 observations, with the exception of the last three, for only 11 subjects were seen with light brown eyes, 23 with brown and 28 whose irises were dark brown.

Judgement of the reaction to pain is based on 12 months use of this new apparatus (Borden high-speed air-rotor), and on more than twenty years clinical experience; nevertheless, it is acknowledged that both types of observation are open to criticism owing to their subjective nature. However, a test to establish the reproducibility of the results was satisfactory, for out of 136 subjects that were re-assessed between one and four weeks after the original examination, the same values were obtained for the colour of the eyes in 115 cases, and for the pain reaction in 114 subjects. Both for colour of iris and for pain reaction, the mean of the discrepancies between each pair of results was non-significant; the mean discrepancies were, pain reaction 0.02, iris colour 0.04.

Approximately 13 per cent of the total number of subjects required the injection of a local analgesic for cavity preparation, a similar percentage being found in the group of subjects formed by adding the results of those whose eyes were greyish-green, green or hazel. However, this aid was not required by any blue-eyed subjects, and was used for only 2 per cent of those with greyish-blue or greenish-grey eyes; but it was required by 30 per cent of the subjects with light brown or brown eyes and by more than 53 per cent of those whose eyes were dark brown.

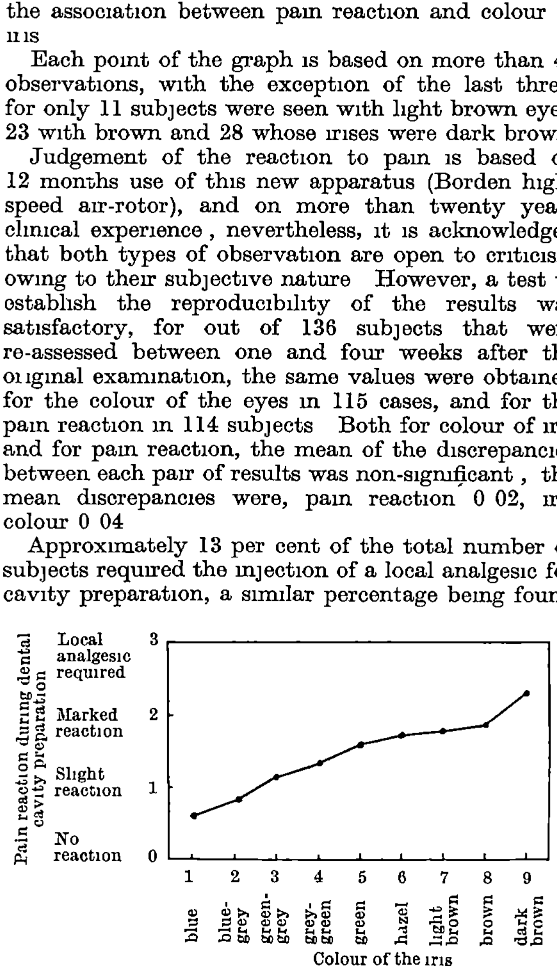


Fig. 1. Association between the colour of the iris and the reaction to pain resulting from dental cavity preparation

My thanks are due to Sir Arthur Amies, and to the University of Melbourne Research Fund.

Philip R. N. Sutton

Dental School,
University of Melbourne.
March 16.

Development of the Aplacophorous Mollusc *Neomenia carinata* Tullberg

Present-day authorities agree that, within the Mollusca, the chitons (or Polyplacophora) are closely related to the solenogastres (or Aplacophora). An important item influencing this view is the description, by Pruvot[1], of the development of seven overlapping, dorsal, plate-like spicules in the metamorphosing larva of the solenogastre, *Nematomenia banyulensis*. The appearance of these spicules has been considered to be a reminiscence of a chiton-like ancestor and, no doubt, has influenced many authors in coming to the conclusion that the solenogastres are degenerate chitons. Pruvot's description was based on observations on a single larva, but nonetheless the figure he gave of this developmental stage has been widely reproduced in general works.

The purpose of the present communication is to describe some observations on the development of *Neomenia carinata* Tullberg 1875; together with the work of Baba[2] on *Epimenia verrucosa*, they show clearly that, while the larva of *Nematomenia* may develop overlapping dorsal plates in the manner described by Pruvot, this is by no means the rule in the Aplacophora.

The embryos of *Neomenia carinata* hatch three days after oviposition (at 10° C.) as trochophores with the blastopore still open abapically, but with no stomodaeum yet developed (Fig. 1*A*). These larvæ swim over the bottom of the culture vessel, propelled by the strong cilia of the prototroch. As the larvæ proceed, they spiral in the same direction as the metachronal waves travel around the prototroch (clockwise when viewed from the anterior). At 7–8 days metamorphosis begins; a caudal bud begins to protrude through what was formerly the blastopore (Fig. 1*B*). The tip of this bud bears a minute pore, the anus, and is ciliated. The rest of the bud, as it grows out, is unciliated but bears large numbers of pointed spicules (Fig. 1*C*). The 'trochophore' part of the larva remains ciliated, but becomes reduced in size, while the prototroch and apical tuft degenerate. The caudal bud comes to form by far the greater proportion of the larva (Fig. 1*D*). The last remains of the ciliated trochophore-mass are ingested through the mouth as the larva completes metamorphosis (Fig. 1*E* and *F*) and abandons pelagic life. At no time is there any trace of segmentation, nor of any dorsal shell-plates. When metamorphosis is complete the external surface of the body (except perhaps for the pedal groove) is unciliated, and the form is like that of the adult *Neomenia*.

This description is based on observations on large numbers of larvæ of *Neomenia carinata* reared through metamorphosis in the laboratory, and the

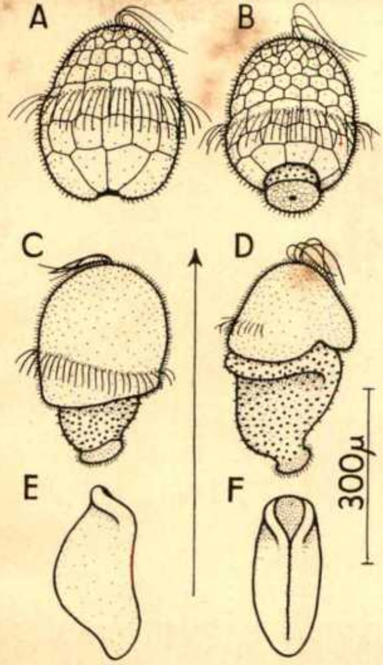


Fig. 1. Metamorphosis of *Neomenia carinata* (camera lucida drawings of live larvæ). *A*, Trochophore at 3 days; *B*, trochophore at 9 days, ventral aspect; *C*, trochophore at 10 days, right lateral aspect; *D*, trochophore at 11 days, right lateral aspect; *E*, newly metamorphosed stage (12 days), right lateral aspect; *F*, the same, ventral aspect. In *E* and *F* the spicules are not illustrated. The arrow shows the antero-posterior axis of the animals

results so far obtained plainly show the need for a re-investigation of the development of *Nematomenia*. At present, the indications are that the nearest relatives of the Aplacophora within the Mollusca may be found in the primitive Lamellibranchia rather than in the Polyplacophora. The resemblances in development between the solenogastres and members of the Brachiopoda, Archiannelida and Nemertea (to which various authors have directed attention) are probably without profound significance. The work on *Neomenia* is being continued and is financed by a grant from the Leverhulme Trust.

T. E. THOMPSON

Marine Biological Station,
Port Erin, Isle of Man.
April 8.

[1] Pruvot, G., *C.R. Acad. Sci., Paris*, **3**, 689 (1890).
[2] Baba, K., *J. Dept. Agric. Kyusyu Univ.*, **6**, 21 (1938).

Dagger Nematodes associated with a Clover Sickness

DAGGER nematodes (*Xiphinema* spp.) are now recognized as important crop pests in many North American states[1-3] and occur widely in tropical countries[4,5] in close association with plant roots. Because of their migratory ectoparasitic habit they are seldom observed feeding on the host plant, and where they appear to be associated with crop damage pathogenicity is difficult to prove.

Examination in early February of 'sickly' white clover (*Trifolium repens* L.) plants from a clover ley near Crewkerne, Somerset, showed no pathogenic organism, but large numbers of dagger nematodes were recovered from the soil around the roots. The roots themselves bore minute lesions compatible with nematode feeding, and many young rootlets were brown and shrivelled at the tip. The field, a sandy loam, had been sown to grass and clover leys in seven out of the past ten years and had a similar early history.

The area was again sampled at the end of April, by which time the clover was dying off in patches. Many dagger nematodes were again recovered, but fungal damage was also evident and small sclerotia, believed to be those of *Sclerotinia trifoliorum* Erikss., were seen; the stem eelworm *Ditylenchus dipsaci* Kühn also occurred in numbers sufficient to constitute a possible cause of disease.

The exact role of dagger nematodes in this complex is thus uncertain; this is the first record of the genus *Xiphinema* in Great Britain, and observations and measurements suggest that the specimens recovered represent a new species, which will be described elsewhere.

F. C. PEACOCK

Imperial Chemical Industries, Ltd.,
Jeacott's Hill Research Station,
Bracknell, Berks.
April 28.

[1] Christie, J. R., *Phytopathology*, **43**, 295 (1953).
[2] Adams, R. E., *Phytopathology*, **45**, 477 (1955).
[3] Schindler, A. F., *Nematologica*, **2**, 25 (1957).
[4] Lordello, L. E. G., *Proc. Helm. Soc. Wash.*, **22**, 16 (1955).
[5] Luc, M., *Nematologica*, **3**, 57 (1958).

Pollen of *Acacia* from Tufaceous Limestone near Udaipur

I HAVE undertaken the investigation of fossil microflora from a tufaceous limestone near Udaipur. This fossiliferous locality is about three-quarters of a mile north-west of the tenth milestone on the Udaipur–Gogunda Road. It was first described by Murty[1], who had suggested a tertiary age to these beds.

A few pieces of fossil were macerated with Schultz's solution and clear dehydrated mounts were prepared by passing the material through various grades of alcohol and mounting in Canada balsam. Some of the preparations were stained with safranin. The

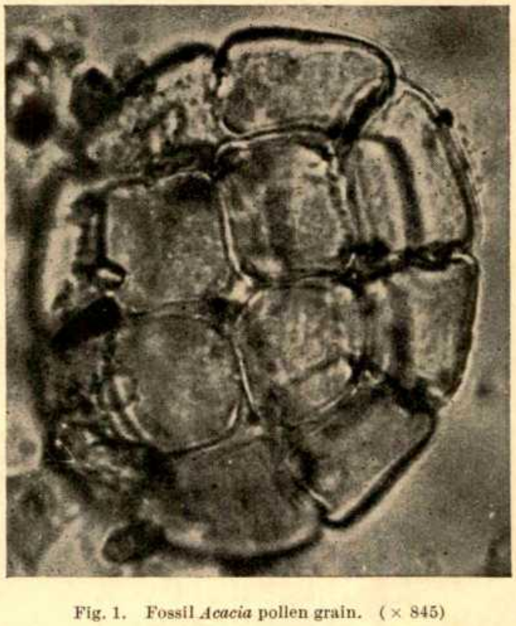


Fig. 1. Fossil *Acacia* pollen grain. (× 845)

slides so prepared showed many angiospermic pollen grains, some of which belong to the Leguminosae and the Gramineae. Also a few pteridophytic spores were observed.

One well-preserved pollen grain resembles very closely that of *Acacia longifolia*. It is a smooth compound 16-celled grain; eight cells are centrally placed, forming a sort of cubical block with the others arranged in a rectangular fashion. The central group is surrounded by eight peripheral cells all in a plane at right angles to, and bisecting, the central group. The peripheral cells are so placed that their eight contacts with each other are alternately opposite and midway between the four contacts of the central group. The group as a whole is flattened, with a more or less rounded outline, and the intersecting lines between the individual grains cross each other at right angles.

The exine is thick and its corners are rounded. The individual grains measure about 24·5μ in diameter and the whole compound grain is 69·5μ in diameter.

It is significant to note that fossil pollen grains of the *Acacia* type have been recently described from the Victorian Tertiary deposits, Australia, by Cookson[2].

I thank Dr. Chitley for her guidance in this work.

T. TRIVEDI

Government College of Science,
Nagpur.

---

[1] Murty, T. V., Proc. Forty-second Ind. Sci. Congr. Assoc. (1955).

[2] Cookson, C. I., *Austral. J. Bot.*, **2** (1), 52 (1954).

ARCHÆOLOGY

Stone Implements from Western Nigeria

RECENTLY a number of stone implements have been uncovered by labourers in sand quarries at Green Springs near Ibadan, Western Nigeria. These implements are associated with deposits of river sand and clay. The workmen wash the sand, discarding the clay and stones, usually placing the latter in heaps or scattering them about the ground. Thus it has not been possible to determine the level at which they were lying before excavation. Generally, however, the layers containing stone are between one and seven feet below the main surface-level.

Table 1 lists the definite artefacts found. The material is mainly quartz from the basement complex.

Polished stone axes are common in Nigeria, where they are often used as protective charms against thieves and thunder, in the belief that they are fallen thunderbolts. Flaked and tanged implements, however, have not previously been recorded from the Western Region of Nigeria, although flaked implements which have been compared to the Chelles–Le Moustier epoch in Europe are found in Northern Nigeria[1], and other flaked implements have been reported from the Eastern Region and the Cameroons[2]. Typologically, the Green Springs implements fall into two groups: (*a*) neolithic types, represented by stone balls, polished axes, anvils, and grinding stones; and (*b*) palæolithic types, represented by the points, the flaked axes and the tanged blade. The latter are suggestive of the Aterian cultures of North Africa[3,4].

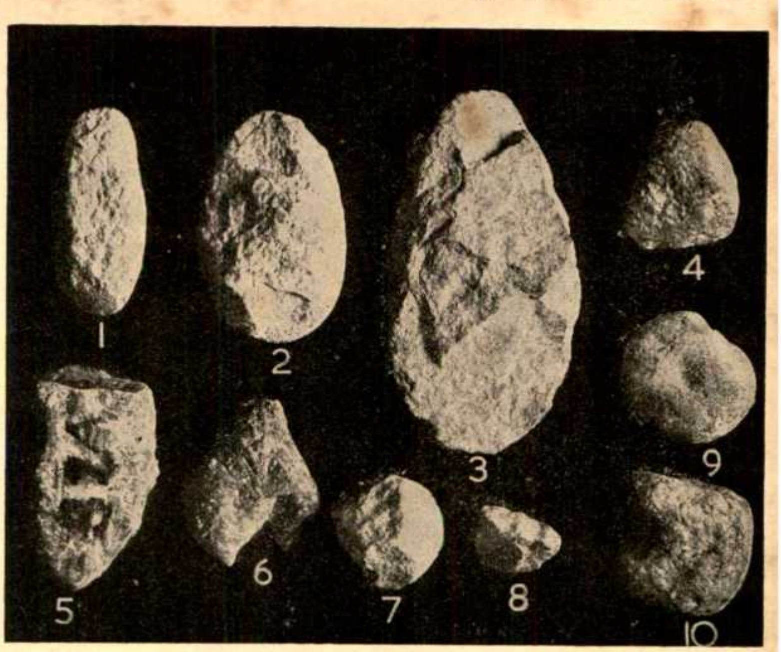


Table 1

Description	Dimensions	No.
Polished hand axes, Fig. 1	Approx. 12 × 6 × 2½ cm.	5
Fragments	Average width : 6 cm.	10
Well-formed bifaced hand axe, Fig. 2	14 × 9½ × 5 cm.	1
Unifaced hand axe, Fig. 3	23 × 12½ × 4½ cm.	1
Polished cleaver-like stone, Fig. 4	7½ × 7 × 3½ cm.	1
'Points', Fig. 5	Approx. 13 × 9 × 2½ cm.	2
Tanged unifaced blade, Fig. 6	11 × 9 × 2 cm.	1
Hand-held polishing or grinding stones, Fig. 7	Approx. 7 × 6 × 6 cm.	3
Bifacial discoid stones (scrapers ?), Fig. 8	Approx. 4 × 6 × 2 cm.	2
Anvil stones indented both surfaces, Fig. 9	Approx. 9 × 7 × 4 cm.	4
Balls	5–8 cm. dia.	15
Eccentrically perforated stone, Fig. 10	Width, 8 cm. ; perf., 2 cm.	1
Fractured stone cylinder	6 cm. dia.	1

We are of the opinion that systematic excavation in the area may be of advantage to pre-history. We wish to acknowledge the kind help of Mr. R. Hockey, geologist, Geological Survey Department, Federal Government of Nigeria.

E. L. KOSTICK
C. N. WILLIAMS
S. A. WILLIAMS

University College,
Ibadan.

March 31.

---

[1] Braunholtz, H. J., "Stone Implements of Palæolithic and of Neolithic Types from Nigeria", Geological Survey of Nigeria, Occasional Paper No. 4 (1926).

[2] Jeffreys, M. D. W., Pan-African Congress on Pre-History, Livingstone, 1955, edit. Clark, J. D., 262 (1957).

[3] Caton-Thompson, G., *J. Roy. Anthrop. Inst.*, **76**, 87 (1946).

[4] Alimen, H., "The Prehistory of Africa", English trans., Chapter 7, 234 (1957).

FORTHCOMING EVENTS

Monday, August 31—Saturday, September 5

10th Congress of the International Astronautical Federation (at Church House, Westminster, London, S W 1)

Wednesday, September 2—Wednesday, September 9

British Association for the Advancement of Science (at York) —Annual Meeting

Wednesday, September 2

At 8 p m —Sir James Gray, C B E , M C , F R S "The Proper Study of Mankind is Man" (Presidential Address)

Thursday, September 3

At 10 a m —Prof L F Bates, F R S "The Visualization of Magnetic Processes" (Presidential Address, Section A)

At 10 a m —Prof M Stacey, F R S "Medical Applications of Complex Carbohydrates" (Presidential Address, Section B)

At 10 a m —Dr L Harrison Matthews, F R S "Man and the World Fauna" (Presidential Address, Section D)

At 10 a m —The late Dr W R G Atkins, F R S "Plants on Land and in the Oceans" (Presidential Address, Section K, read by Dr C P Spencer)

At 10 a m —Dr H G Sanders "Balance in British Farming" (Presidential Address Section M)

At 11 15 a m —Mr W R Day "The Influence of Pathogenic Factors within the Rooting Space on the Development of Even-aged Plantations" (Chairman's Address, Section K*)

At 11 30 a m —Sir Ewart Smith, F R S "The Critical Importance of Communication and Transport" (Presidential Address, Section G)

At 2 30 p m —The Countess of Albemarle "Living with Science" (Presidential Address, Section X)

Friday, September 4

At 10 a m —Prof K C Edwards "Trends in Urban Expansion" (Presidential Address, Section E)

At 10 a m —Prof John Jewkes "How Much Science ?" (Presidential Address, Section F)

At 10 a m —Sir James J Robertson "What Are Our Schools For ?" (Presidential Address, Section L)

At 11 30 a m —Prof Magdalen Vernon "Perception, Attention and Consciousness" (Presidential Address, Section J)

At 8 p m —Prof M Swann "The Unseen Pattern of Growth" (Evening Discourse)

Sunday, September 6

At 10 30 a m —Official Service at York Minster Preacher The Most Reverend The Lord Archbishop of York

Monday, September 7

At 10 a m —Prof O M B Bulman, F R S "Recent Developments and Trends in Palæontology" (Presidential Address, Section C)

At 10 a m —Prof Ian A Richmond "The Nature and Scope of Archæology" (Presidential Address, Section H)

At 10 a m —Prof A Hemingway "Artificial Organs—Biological Applications" (Presidential Address, Section I)

At 8 p m —Sir William Hildred "International Air Transport Problems" (Evening Discourse)

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned

Analyst (qualified for general inorganic analysis) in the Houldsworth School of Applied Science, mainly for work on silicates—The Registrar, The University, Leeds 2 (August 31)

Lecturer in Mathematics , Lecturers (2) in Geography , and Lecturers (2) in Education at Palmerston North University College, (Victoria University of Wellington), New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (New Zealand, August 31)

Lecturer (preferably with experience in solid-state or low-temperature physics or ultrasonics) in Physics—The Registrar, Queen Mary College, Mile End Road, London, E 1 (August 31)

Assistant Lecturer (preferably with interests in plant physiology and plant ecology) in Botany—The Principal, Royal Holloway College (University of London), Englefield Green ,Surrey (September 1)

Senior Lecturer and Director (with high academic qualifications and experience of high-speed digital computers) of the Sub-Department of Computation—The Secretary and Registrar, The University, Southampton (September 1)

Assistant Lecturer or Lecturer in the Department of Agricultural Economics—The Registrar, University College of Wales, Aberystwyth (September 5)

Laboratory Steward in the Department of Botany—The Registrar, University College, Singleton Park, Swansea (September 8)

Lecturer in Zoology in the University of Queensland, Australia —The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, September 11)

Assistant Lecturer in Dairying—The Registrar, University College of Wales, Aberystwyth (September 12)

Lecturer in Pure Mathematics , Senior Tutors (2) in Pure Mathematics , and a Senior Lecturer in Physical Metallurgy at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, September 19)

Lecturers (2) in Astronomy in St Salvator's College, University of St Andrews—Joint Clerk to the University Court, College Gate, St Andrews (September 19)

Lecturer in Education at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (New Zealand, September 20)

Senior Tutor-Demonstrators (2) in Zoology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, September 26)

Lecturer in Mathematics at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, September 30)

Lecturer in Geography at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 1)

Mycologist (with a good honours degree in botany, with mycology as a special subject, a knowledge of the more fundamental aspects of animal and human mycoses, and preferably a knowledge of Latin and other languages) at the Commonwealth Mycological Institute, Kew—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (November 30)

Junior Plant Breeder (male, with a good honours degree in botany with postgraduate experience in the technique of plant improvement) at the West African Cocoa Research Institute (serving initially at Tafo, Ghana), to carry out research on plant-breeding problems relating to cocoa—The Director of Recruitment, Colonial Office, London, S W 1, quoting BCD 197/200/08/T

Lecturer in Physics, and an Assistant Lecturer in Physics (Grade "B')—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N 7

Senior Lecturer in Zoology—The Registrar, Bradford Institute of Technology, Bradford 7

Technician in the Zoology Department—The Secretary, Royal Holloway College, Englefield Green, Surrey

REPORTS and other PUBLICATIONS

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Abstracts of Dissertations approved for the Ph D , M Sc , and M Litt Degrees in the University of Cambridge during the Academical Year 1956–57 Pp xviii+267 Titles of Dissertations approved for the Ph D , M Sc , and M Litt Degrees in the University of Cambridge during the Academical Year 1957–1958 Pp iv+25 (Cambridge Board of Research Studies, The University, 1959) [144

British Electrical and Allied Industries Research Association Technical Report E/T65 The Low Temperature Liquid Phase Oxidation of Hydrocarbons a Literature Survey By Prof Frank Morton Pp 33+8 figures 21*s* Technical Report L/T365 Ultra-High Frequency Gas Breakdown between Rogowski Electrodes By W A Prowse and J L Clark Pp 15+25 figures 18*s* Technical Report L/T368 Effects of Coulomb Forces on the Conduction Properties of Semi-Conductors By S Doniach Pp 37 18*s* Technical Report L/T371 The Calculation of Insager's Reaction Field for a Particular Model By B V Paranjape Pp 8+2 figures 7*s* 6*d* Technical Report Z/T117 Evolution of Extra-Galactic Nebulae and the Origin of Metagalactic Radio Noise By Dr C E R Bruce Pp 7 9*s* (Leatherhead British Electrical and Allied Industries Research Association, 1955, 1957 and 1958) [144

Polish Cultural Institute, London Selective Quarterly Guide to Polish Periodical Literature, Vol 4, 1, 1959 Pp i+76 (London Polish Cultural Institute, 1959) [144

Federation of British Industries Forty-second Annual Report, 1958 Pp vi+42 (London Federation of British Industries, 1959) [144

Rowett Research Institute Collected Papers, Vol 15 Reprints Nos 1–88 Collected Papers—Summary and Subject Reviews, Vol 15 Pp 50 (Bucksburn Rowett Research Institute, 1959) [174

Capital Investment in the Coal, Electricity and Gas Industries Pp 8 (Cmnd 713) (London H M Stationery Office, 1959) 6*d* net [174

Ministry of Power Reports of H M Inspectors of Mines and Quarries under the Mines and Quarries Act 1954, for 1958 North Eastern Division By H J Perrins Pp iii+46+4 plates (London H M Stationery Office, 1959) 3*s* 6*d* net [174

New Developments in Training Five Studies in the Efficient Communication of Skills Edited by Frank A Heller (New Development Series, No 3) Pp 80 (London Polytechnic Management Association, 1959) 5*s* [174

Quercus L By Eustace W Jones (Biological Flora of the British Isles, No 68 Reprinted from the *Journal of Ecology*) Pp 169–222 (Oxford Blackwell Scientific Publications, 1959) 8*s* 6*d* [174

Imperial Cancer Research Fund Fifty-sixth Annual Report, 1957–1958 Pp 39 (London Imperial Cancer Research Fund, 1959) [174

Anti-Locust Bulletin No 32 The Colour Patterns of Hoppers of the Desert Locust (*Schistocerca gregaria* Forskal) By Dr W J Stower Pp ii+75+17 tables, 24 figures and 5 coloured plates (London Anti-Locust Research Centre, 1959) 45*s* [174

Ministry of Housing and Local Government Second Progress Report of the Standing Technical Committee on Synthetic Detergents Pp 10 (London H M Stationery Office, 1959) 9*d* net [174

Association of Agriculture Annual Report for 1958 Pp 12 (London Association of Agriculture, 1959) [174

Ciba (A R L), Limited Technical Notes No 196, (April, 1959) Glued Timber Fans and Impellers Pp 10 (Duxford Ciba (A R L), Limited, 1959) [174

Other Countries

United States National Museum Bulletin No 216 Ichneumon-Flies of America North of Mexico 1 Subfamily Metopiinae By Henry and Marjorie Townes Pp ix+318 (Washington, D C Government Printing Office, 1959) 1 25 dollars [174

Science Information News, Vol 1, No 1, (February-March, 1959) (Reporting National and International Developments in Scientific and Technical Information) Published bi-monthly Annual subscription 1 75 dollars Single copies 25 cents (Washington, D C National Science Foundation, 1959 Obtainable from Superintendent of Documents, U S Government Printing Office, 1959) [174

United States Department of Agriculture Leaflet No 444 The Narcissus Bulb Fly How to Prevent Its Damage in Home Gardens By C F Doucette Pp 9 (Washington, D C Government Printing Office, 1959) 5 cents [174

Records of the Australian Museum Vol 24, No 7 Variation in the Australian Kingfishers (*Aves Alcedinidae*) By Allen Keast Pp 61–72 Vol 24, No 8 Variation and Speciation in the Australian Flycatchers (*Aves Muscicapinae*) By Allen Keast Pp 73–108 Vol 24, No 9 New Upper Permian Homopters from the Belmont Beds (Homoptera Insects) By J W Evans Pp 109–114 Vol 24, No 10 The Permian Gastropods of New South Wales By H O Fletcher Pp 115–164+plates 7–21 Vol 24, No 11 Liotiidae and Allied Molluscs from the Dampierian Zoogeographical Province By Charles F Laseron Pp 165–182 Vol 24, No 12 A Key to the Australian Families of Acalyptrate Diptera By David K McAlpine Pp 183–190 (Sydney Australian Museum, 1957 and 1958) [174

Smithsonian Institution United States National Museum Proceedings of the United States National Museum No 3407 Synopsis of the Species of Agromyzid Leaf Miners described from North America By Kenneth E Frick Pp 347–465 No 3409 Scarab Beetles of the Genus *Bothynus* in the United States (Coleoptera Scarabaeidae) By O L Cartwright Pp 515–541 No 3410 A Further Study of Micronesian Polyclad Flatworms By Libbie H Hyman Pp 543–597 (Washington, D C Government Printing Office, 1959) [174

National Science Foundation Scientific Research and Development in Colleges and Universities Expenditures and Manpower, 1953-54 Pp iii+173 (Washington, D C Government Printing Office, 1959) 1 dollar [174

Annals of the New York Academy of Sciences Vol 74, Article 3 Chlorpropamide and Diabetes Mellitus By Martin G Goldner and 178 other authors Pp 407–1028 (New York New York Academy of Sciences, 1959) 5 dollars [174

United States Department of the Interior Fish and Wildlife Service Fishery Bulletins No 121 Fecundity of the Pacific Sardine (*Sardinops caerulea*) By John S MacGregor Pp iii+427–449 25 cents No 122 Fecundity of North American Salmonidae By George A Rounsefell Pp ii+451–468 20 cents No 123 Effects of Unialgal and Bacteria-Free Cultures of *Gymnodinium brevis* on Fish, and Notes on Related Studies with Bacteria By Sammy M Ray and William B Wilson Pp iii+469–496 25 cents No 124 Observations on the Spearfishes of the Central Pacific By William F Royce Pp ii+497–554 40 cents No 125 Treatment of Sulfonamide-Resistant Furunculosis in Trout and Determination of Drug Sensitivity By S F Snieszko and G L Bullock Pp ii+555–564 15 cents No 126 Natural Mortality Rate of Georges Bank Haddock By Clyde C Taylor Pp ii+1–7 15 cents No 127 Accelerated Development of Testis After Unilateral Gonadectomy, with Observations on Normal Testis of Rainbow Trout By O H Robertson Pp iii+9–30 25 cents No 128 Description and Distribution of Larvae of Four Species of Tuna in Central Pacific Waters By Walter M Matsumoto Pp ii+31–72 30 cents No 129 Filtering Rates of the Hard Clam (*Venus mercenaria*) determined with Radioactive Phytoplankton By T R Rice and Rebecca J Smith Pp ii+73–82 15 cents No 130 Factors Causing Decline in Sockeye Salmon of Karluk River, Alaska By George A Rounsefell Pp iii+83–169 55 cents No 131 Anadromy in North American Salmonidae By George A Rounsefell Pp ii+171–185 20 cents (Washington, D C Government Printing Office, 1957 and 1958) [174

United States Department of Agriculture Technical Bulletin No 1196 Sulfur Content of Rainwater and Atmosphere in Southern States as Related to Crop Needs By Howard V Jordan, Charles E Bardsley, Jr and J A Lutz Pp ii+16 (Washington, D C Government Printing Office, 1959) 10 cents [174

Tokyo Astronomical Observatory Tokyo Astronomical Bulletin Second Series No 109, (October 5, 1958) Frequency Change due to Doppler Shift in WWVH Signals as received at Tokyo, (1) By S Iijima, Y Ohki and I Oguma Pp 1173–1181 No 110, (October 10, 1958) Photographic Observations of Variable Stars (3) By S Kaho Pp 1183–1194 No 111, (November 20 1958) Photo-Electric Observations By H Hirose, K Tomita, R Manabe, M Utida, Y Kozao, S Kaho and T Takenouchi Pp 1195–1203 No 112, (November 20, 1958) Air-borne Sun Pointing Device and Its Test at the Annular Eclipse on April 19, 1958 By Kuniji Saito and Keizo Nishi Pp 1205–1214 (Tokyo Tokyo Astronomical Observatory, 1958) [174

Administration Report of the Government Museum, Madras, the National Art Gallery, Madras, The Government Museum, Pudukkottai, and the Connemara Public Library, (Exchange Section), Madras, for 1956–57 Pp ii+103 (Madras Government Museum, 1958) [174

United States Department of Commerce Weather Bureau Technical Paper No 32 Upper-Air Climatology of the United States Part 3 Vector Winds and Shear By Benjamin Ratner Pp ii+6 (Washington, D C Government Printing Office, 1959) 50 cents [174

Transactions of the American Philosophical Society New Series Vol 49, Part 2 Edward T Cardwell—Peelite By Prof Arvel B Erickson Pp 107 (Philadelphia American Philosophical Society, 1959) 2 dollars [174

United States Department of the Interior Fish and Wildlife Service Fishery Bulletins No 133 Experimental Exploitation of Fish Populations By Ralph P Silliam and James S Gutsell Pp ii+215–252 20 cents No 134 Analysis of Catch Statistics of the Hawaiian Skipjack Fishery By Daniel T Yamashita Pp ii+253–278 25 cents No 135 Uptake and Accumulation of Radioactive Zinc by Marine Plankton, Fish, and Shellfish By Walter A Chipman, Theodore R Rice and Thomas J Price Pp ii+279–292 15 cents (Washington, D C Government Printing Office, 1958) [174

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United States Department of the Interior Geological Survey Water-Supply Paper 1352 Quality of Surface Waters of the United States, 1954 Parts 7–8 Lower Mississippi River Basin and Western Gulf of Mexico Basins Prepared under the direction of S K Love Pp x+499 1 75 dollars Water-Supply Paper 1426 Ground-Water Resources of the Hueco Bolson Northeast of El Paso, Texas By D B Knowles and Richard A Kennedy Pp iv+186+11 plates n p Water-Supply Paper 1460–E Geological and Geophysical Study of the Preglacial Teays Valley in West-Central Ohio By Stanley E Norris and H Cecil Spicer Pp iii+199–232+plates 7 and 8 55 cents Water-Supply Paper 1477 Annotated Bibliography on Artificial Recharge of Ground Water Through 1954 By David K Todd Pp iii+115 50 cents Professional Paper 294–J Conodonts from the Chappel Limestone of Texas By Wilbert H Hass Pp iii+365–399+plates 46–50 n p (Washington, D C Government Printing Office, 1959) [174

Fertilizers Production, Consumption, Prices and Trade in Europe—8th study, 1956–1959 Pp 91 (Paris Organization for European Economic Co-operation, London H M Stationery Office, 1959) 44 French francs, 7*s*, 1 25 dollars, 4 50 Swiss francs [284

New Zealand Forestry Research Notes No 14 Combined Taper and Volume Tables for European Larch—New Zealand, 1956 By S W Burstall Pp 22 (Wellington Government Printer, 1958) [284

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge Série Scientifique No 75 Moisissures du Sol et des Litières de la Région de Yangambi (Congo Belge) Par J Meyer Pp 211+4 planches (Bruxelles Institut National pour l'Étude Agronomique du Congo Belge, 1959) 190 Belgian francs [284

Register of Current Scientific Research at South African Universities, 1958 Pp viii+235 (Pretoria South African Council for Scientific and Industrial Research, 1958) [284

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO, LTD,
ST MARTIN'S STREET, LONDON, W C 2
Telephone Number Whitehall 8831 Telegrams Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

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Telephone Number Holborn 4743

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SCIENCE AND SOCIETY

IN an address at the California Institute of Technology on June 12, the substance of which appears on p. 135 of this issue, Sir Solly Zuckerman remarked that the element of the unknown in government increases with every step we are now taking to apply the fruits of science, and that if, as some consider, sovereign power is being abrogated, it is not to some governing body, however formed, but more and more to a process of applying scientific knowledge without any real possibility of determining its final consequences. Dr. Brian Chapman closed his recent book, "The Profession of Government"*, with the remark that in the past hundred years in Europe arbitrary power has been replaced by anonymous power, and anonymous power is the antonym of public administration. It is, in fact, in the context of the problem of government that Sir Solly approaches his subject of liberty in an age of science, and the second main point to which he directs attention is that science, itself demanding freedom and revolutionary in its ways, is now determining, in an increasingly unpredictable way, the main issues about which citizens exercise their freedom of choice. This involves consideration of both the means and the purpose of government.

Sir Solly Zuckerman begins in a way which recalls Sir Charles Snow's Rede Lecture, and also Dr. P. A. Weiss's address, "The Message of Science", at Brussels last year, by discussing the divergence between the scientist and the humanist, quoting George Gissing's fear that science would become the remorseless enemy of mankind, before he goes on to explain the nature of science itself and of its dependence on freedom. For the scientist this means not only the freedom to choose his own problems to investigate, but also the fact that significant advances in scientific knowledge cannot be ordered by decree. Because scientific advance is unpredictable, "the untrammelled emergence of new scientific ideas is not compatible with any restraint on the liberty of the scientist to roam where his fancy leads. Indeed, once the growth of any set of scientific ideas becomes constrained, they are in danger of becoming obstructive dogma".

It is this freedom of science even to be revolutionary that raises doubts and even controversy if stability is to be achieved in a world in which the impact of science is so profound, and Sir Solly Zuckerman points that out; while the growth of fundamental scientific knowledge necessitates complete freedom from restraint, science is not uniquely associated with the preservation of freedom either in the personal or the social sphere. The applications of science have indeed provided the apparatus which has made central government powerful alike in a democratic and in an authoritarian regime. Science itself has no inherent moral direction, and while science will be the handmaiden of equality in the economic sphere, given the appropriate political institutions, our social environment is constantly being transformed by new scientific ideas and by the application and practical development of those ideas.

It is in this way that science helps to define for us the content and boundaries of the area within which we exercise our freedom; and in this sense only, the sense in which freedom was conceived by the utilitarians of the industrial revolution, science can be described as the handmaid of freedom. Through its practical impact, science to an increasing—almost to a dominant—extent is determining the way in which the sovereign power expresses itself, and here Sir Solly asks whether in choosing to regulate our lives in accordance with scientific discovery we know for what it is we are opting. "Is the sovereign power consciously deciding to develop this or that scientific discovery, and so to determine social development in this or that direction ?"

The answer to any of these questions is inevitably bound up both with the constraints and the unpredictability of any major scientific advance. Moreover, as Sir Solly himself reminds us, scientific knowledge never develops evenly over the whole potential field of knowledge, and by choosing one out of several possible courses of action in search of a solution to a problem, the scientist may deny himself, and others, the opportunity of pursuing another. That applies still more to the choice of problems to be investigated, as the recent debate over Britain's decision to enter the field of space research should sufficiently illustrate, and beyond difficulties due to the increasing complexity of scientific knowledge and its application lies the impossibility of defining in advance the nature and magnitude of potential discovery or its impact on our social lives. Moreover, there may well be unforeseen and unexpected secondary social effects, as is well illustrated in Dr. Michael Young's discussion of possible effects of selection on the basis of intelligence tests in his book, "The Rise of the Meritocracy". Well may it be asked whether there can be much more than a fictional verity in the abstract idea that an area exists within which men can enjoy the capacity of unconditioned or untrammelled choice.

Sir Solly seems to recognize clearly enough that this is ultimately a problem of government rather than of philosophy. His remark that the only form of exploitation which democracy—man's answer to tyranny and exploitation—will never overcome is the coercion of new knowledge, which, by guiding our social lives into certain channels, limits advance in other directions, should be pondered in the light of the clear warning about the dangers of secrecy which Dr. Brian Chapman gives in his final chapter. Dr. Chapman is exposing the stupidity of secrecy from the point of view of relations between the government and the public All that he writes, however, about the futility of the pathological secretiveness of the British Government, matched in Europe only in Spain and Portugal, applies even more forcefully where science is concerned These attempts at secrecy merely hinder scientific or technical advance without promoting security and, more serious, impede the informed public discussion and understanding of what both science and Government are doing which is essential if science is to be wisely used

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* The Profession of Government: The Public Service in Europe. By Dr. Brian Chapman. Pp. 352. (George Allen and Unwin, Ltd., 1959.) 28s. net.

This is even more important now that we stand at the cross-roads, as Sir Solly reminds us Hitherto, we could claim that the applications of science have increased the sum total of human happiness The process of applying scientific knowledge is as endless as is the prospect of getting new knowledge, and we can be reasonably certain that neither the backward and under-developed nor the rich nations will allow the process of applying the fruits of scientific knowledge to stop, either in the national or the international framework In this process, however, means become ends, because as new ways of doing things are discovered, they transform the things done, and so their purpose In fact, weapons may end by determining strategy and even the purpose behind the strategy

Here, in Sir Solly's view, arises the real clash to-day between the scientist and the humanist, and this form of scientific application could indeed constrain our democratic liberties and even, if we ceased to be vigilant, the liberty of science itself That would seem to imply a special responsibility for the scientist, though Sir Solly does not agree that such a responsibility means more than that the scientist is better able to appreciate scientific facts It is not reasonable, he points out, to expect the scientist as such, who is not responsible for the application, to accept the responsibility for predicting some vast social transformation which might result from a seemingly innocent observation

Nor is that all, for it has to be remembered that the process of government involves much more than taking account of scientific and technical factors and their implications Even if the problem is essentially a scientific one, the statesman or minister who has to take a decision and formulate a policy must have regard to public acceptability, and accordingly to the public understanding Normally there will be many other factors to be considered, and it is the consequences of the application of science that are of most concern, since they are most readily appreciated by the public and most relevant politically

It is noteworthy that in this connexion Sir Solly Zuckerman reaches the same conclusion as to the importance of education as do Dr Chapman and Mr C H Sisson in another recent book on government* Sir Solly suggests that in this problem of preserving our liberties lies the most important reason for regarding an education in science as constituting to-day an essential part of an education in the humanities An understanding of social and political purpose can no longer be realized through the liberal arts, unless their scope is widened to embrace a proper understanding of the scientific knowledge the application of which is so rapidly transforming our intellectual and material environment

It is with realism and not arrogance that Sir Solly places science, technology and humanism in that order of importance in determining our affairs , and in the same spirit that he suggests that, to continue as a potent educational discipline, the humanities must encompass an understanding of the social forces which arise from the application of the natural sciences Nor does he suggest that higher education necessarily guarantees higher virtue or higher political wisdom , rather we are likely to avoid bad decisions if we realize that decisions taken in major scientific matters to-day may determine the course of the future Dr Chapman comments that no other European country has emphasized to the same extent as Britain the strange division between science and the humanities, with the result that the common difficulty of finding adequate numbers of Civil servants with sufficient specialized training is accentuated , nevertheless, he recognizes that all branches of the public service, ministries as well as industrial public enterprises, need a proper balance between administrator, manager and technician, and that ministries often lack technical competence in scientific, industrial and economic fields

Apart, however, from referring to the way in which France has been able to meet some 90 per cent of her requirements for first-class engineers and technologists with administrative experience, Dr Chapman does not discuss the place of the scientist or technologist in administration He stresses the importance of education and recognizes that this means the education of the general public as well as of the administrator, and the politician and minister He makes the significant comment that a menial mind should not be a qualification for high administrative office , but his constructive criticism is rather on the structure of the Civil Service itself, where it points to the fresh thinking that is required in order that the public services may be able to fulfil the needs of the modern State

Nor are his suggestions for the Civil servant or the minister alone they are no less worthy of the attention of professional organizations, for they point to ways in which not merely could the public services be absorbed more effectively into the structure of the modern State, but also, and no less important, the professional scientist or technologist could serve the State under conditions less likely to constrain professional ideas and tradition Mr C H Sisson, in "The Spirit of British Administration", is less confident as to the possibility of a general liberality, though he believes just as firmly as Sir Solly Zuckerman and Dr. Chapman that the survival of some kind of liberal and general education is indispensable to the survival of parliamentary government or indeed of any government based on free discussion, with this goes the survival of administrators who are not daunted by specialists but take it for granted that the practical implications of all their work can be explored and explained by a sufficiently agile lay mind

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* The Spirit of British Administration and some European Comparisons By C H Sisson Pp iv+162 (London Faber and Faber, Ltd , 1959) 21*s* net

The defence of freedom is a central problem of our time, and it is not simply one of defence against aggression from totalitarian systems outside Sir Solly Zuckerman shows clearly how it arises from the nature of science itself, and from the impact of science on society Any scientist or technologist who is concerned about those changes and how they can be best avoided or minimized will be led inevitably to think not simply about the association of scientist or technologist with government but about the process of government itself To such thinking both the books mentioned above offer some contribution in different ways they can assist in the understanding of the nature of administration and the limitations within which the administrator works, they indicate also the mind of the administrator and how it is trained or formed, and they point to some of the ways in which reform or developments are required if the task of government is to be discharged adequately to-day But, like Sir Solly Zuckerman's address, they are primarily a challenge to the scientist or technologist to accept such responsibility to-day, and a stimulus to the creative thought by which alone that responsibility can be discharged

THE NEED FOR MARINE RESEARCH

Living Resources of the Sea

Opportunities for Research and Expansion By Dr Lionel A Walford (A Conservation Foundation Study) Pp xv+321 (New York The Ronald Press Company, 1958) 6 dollars

IT is more than sixty years since the foundation of the International Council for the Exploration of the Sea, the avowed purpose of which is the accumulation of knowledge necessary for the rational exploitation of marine resources in northern waters There are now a dozen or more councils or commissions covering other areas of the world, including commissions limited to certain animals, such as halibut, salmon, tuna, and whales The fear of over-fishing, which has been the spur to the activity of the International Council, the Halibut Commission, and other more recently formed organizations, has always been well to the fore in the minds of those concerned with the science of the sea The necessary research has been concentrated on the main northern fisheries, but now the demand to feed the under-nourished millions has focused attention on the sea as a whole as a possible source of protein

At the request of the Conservation Foundation, Dr Lionel A Walford, chief of the Biology Branch of the U S Fish and Wildlife Service, was asked to explore the question "What scientific researches, apart from those which are in progress, would contribute significantly toward learning how to enlarge the yield of food from the sea in answer to human needs ?" This has resulted in a useful book in which Dr Walford considers the problem from human and biological angles The major conclusion is that research must be extended into those areas where the need is greatest, and where there is the most possibility of increasing the food supply where it is most lacking A number of interesting charts are included indicating the existing intensity of fishing and research in different parts of the world, those areas of the sea which might be expected to be productive, and those on land where the need for food is greatest This survey impresses on us that where the fisheries are at present most developed and exploited there lies the major effort of research The number of pertinent marine laboratories is now about 240 Nearly 90 per cent of these are in the northern hemisphere and 85 per cent north of latitude 20° N Thus, those areas in which the need for research is now greatest have least facilities to do so both in material equipment and trained personnel The problem is one both of research and development, and it is not easy to do the former without the latter unless exploration for fishing grounds is subsidized by governments

It is thus both humanely and politically advisable that the countries most advanced in marine research should do their utmost to help the under-developed areas Since the Second World War fisheries research under the auspices of Her Majesty's Colonial Office has added significantly to knowledge in certain areas, the U S Fish and Wildlife Service has extended its investigations into the oceanic pelagic fisheries, and the United Nations Food and Agriculture Organization has helped in supplying experts and supervising training But this effort should if possible be much increased, and every encouragement given to those who wish to do research that will add to our knowledge of conditions in tropical seas

Dr Walford's book is not a text-book, it attempts to show where lie the gaps in knowledge, and these are both large and numerous As a single example, what do we know of the probably enormous food potentialities available in pelagic cephalopods which now constitute 60 per cent of the Japanese fisheries ?

Marine resources are also not necessarily all of value as food, some may have medical value On our own planet there lies a whole world which we have only recently begun to study extensively. It is to be hoped that Dr Walford's book may stimulate us to greater efforts.

F S. RUSSELL

ANOTHER DEBT TO DARWIN

Index Kewensis

Plantarum Phanerogamarum Supplementum Duodecimum Nomina et Synonyma Omnium Generum et Specierum ab Initio Anni MDCCCCLI usque ad Finem Anni MDCCCCLV Nonnulla etiam antea Edita Complectens, Ductu et Consilio Georgii Taylor, confecerunt Herbarii Horti Regii Botanici Kewensis Curatores Pp iii+157 (Oxonii E Prelo Clarendoniano, 1959) 75*s* net

IN this centenary year of the publication of the "Origin of Species" biologists have very much in mind the debt that they owe to Charles Darwin It is probable, nevertheless, that many of them do not remember that the inception of "Index Kewensis" was due not only to Darwin's perception of the necessity for such a work but also to his generosity in providing the funds

We might at this moment remember that the work was started under the supervision of Darwin's great friend, J D Hooker, and has since been supervised by subsequent directors of Kew and carried out by numerous able, but often anonymous, helpers

"Index Kewensis" is taken so much for granted by plant taxonomists working with angiosperms that it is often not fully appreciated To anyone who has struggled, even briefly, with taxonomic and nomenclatural problems in groups such as algae, where no such index exists, the lack of it is keenly felt and the value of a catalogue of names with places of publication is soon fully realized It is interesting to note in this connexion that an "Index Muscorum" is due to be published shortly—another descendant of the original Darwinian idea

"Index Kewensis", the twelfth quinquennial supplement to which has now been published under the direction of Dr G Taylor, supplies far more information about flowering plants and papers concerning them than might at first sight appear

For example, in the five-year period between 1951 and 1955 approximately 12,000 species of flowering plants have been described This, after more than two centuries of taxonomic work in the post-Linnean period, is a staggering total and gives some measure of the imperfection of our knowledge of the dominant group of plants

It is also easy to obtain from these Supplements references to important monographs and information about the geographical areas and the plant groups which have been the subject of special attention in the recent past, as well as the names of the workers concerned

In conclusion, I may perhaps be allowed to repeat what has so often been said before "Index Kewensis" is indispensable T G. Tutin

OPTICS: CLASSICAL AND MODERN

Concepts of Classical Optics

By Dr John Strong Pp xxii+692 (San Francisco W H Freeman and Company, London Bailey Bros and Swinfen, Ltd, 1958) 9 50 dollars, 80*s*

THIS is a very good book, and one of its best features is the care taken by the author to ensure that the student understands what is going on Mathematical treatment is kept to a minimum, but where it is necessary we are not left to flounder, the author explains what he is doing by means of a sort of running commentary, and even reassures us that although the solution we are after is buried in complication at the moment it is going to emerge safely in a minute The only criticism here is that some simplification of the symbols used would lead to even greater clarity, for example, why was it necessary to use the symbol λ for mass early in Chapter 1, only to announce, a few pages later, that "we now abandon this for its customary use, symbolizing wavelength"?

The author also takes the trouble to expose and explain theoretical difficulties which are too often ignored A good example of this is the section on "No Diffraction, by Cornu's Spiral", in which the limitations of this construction are pointed out, with the conclusion that "it affords the student an example of a typical theory in physics which has an impressive neatness, inspiring awe, which makes necessary compromises, requiring prudence, which is blemished by a lack of complete validity, requiring understanding"

At first glance the most distinctive feature of the book is the character of the illustrations These are in the style one associates with the author's well-known book on laboratory practice They have a freehand appearance, are pleasant to look at and are extremely clear, for example, the drawings in the section on double refraction, which is inherently a difficult subject to illustrate, are models of clarity What is even more important is that the drawings showing apparatus give one a good idea as to how it is actually constructed—too often one's first sight of the actual equipment comes as a shock after having seen only text-book illustrations It is only in some of the attempts to reproduce optical images by means of sketches that actual photographs might have been better

The book is described in the preface as being intended for an intermediate course in optics, taking one or two terms This is a considerable under-statement of the ground covered, and the book should be valuable for much more advanced students and also for general reference purposes It in fact covers most of the physical optics required for an honours degree in physics

The only real adverse criticism of this book concerns the price—£4—which is surely at least twice as much as most students would willingly pay for a single book This is to some extent offset by the seventeen so-called appendixes, which occupy nearly half the book, and are in effect a series of short monographs by specialists To quote the preface "these are intended to give the student the flavour of current activities and interests in our field" The topics covered in this way include, among other things, interferometers, apodization, Fourier transformations and interferometric spectroscopy, radiation detectors, micro-wave optics, wave theory of image formation, lens design, fibre optics and filters One of the appendixes supplies some of the mathematical background assumed in the rest of the book This is well done, and includes frequent attempts to make the student think—both by formal examples and by interjected questions such as "(why?)" or "(how do we know?)" after mathematical steps in the text J E Geake

BLOOD GROUP METHODS AND TECHNIQUES

Practical Blood Grouping

By Dr F Stratton and Dr P H Renton Pp xxiv+331+16 plates (Oxford Blackwell Scientific Publications, Springfield, Ill Charles C Thomas, Publisher, 1958) 42*s* net

OVER the past fifteen years mass grouping of blood donors and ante-natal cases has grown enormously, and of necessity special methods and techniques have been evolved to meet an entirely new situation

The authors of this book, faced with the alternatives of describing a multiplicity of methods, or confining themselves to those known and well tried in their own laboratory, have wisely chosen the latter

Not all would agree that the papain slide test offers substantial advantages over existing (and equally well-tried) techniques, for example, tube testing Even if some small advantage could be demonstrated, the disorganization which would follow a drastic change to a new technique would carry inherent dangers, probably outweighing any benefits likely to result

Nevertheless, it is always of value to study methods which have proved satisfactory over a number of years, and many pathologists engaged in this work will be most interested in a method which has satisfied such critical observers as the writers

In the section dealing with ante-natal grouping, the possible alternative to the current practice of ABO and Rh(D) screening, with the customary follow-up of the Rh(D) negatives, is attractive from the point of view of economy in laboratory working It might, however, be difficult to convince clinicians, and particularly obstetricians, that this economy at the expense of their advance knowledge of their patients' groups would be justified It is certain that they would argue, as is foreseen by the authors, that obstetric emergencies would not be so well covered

It would seem that the writers themselves have not adopted this possible alternative in their own practice, having doubtless explored the possibilities and the difficulties which it would entail

An interesting and informative chapter on cross-matching difficulties encountered in their own laboratory (p 237) was found to be slightly confusing For example, of the 2,967 cases involved the donor's blood was not of the ABO group as stated on the bottle in two cases

Without knowing the total number from which the 2,967 are selected the two wrongly labelled bottles may or may not represent a much higher proportion of error than is considered unavoidable in an earlier chapter

In any event, some explanation of how these two bottles escaped the rigid checks and cross-checks, described in detail in Chapter 7, where the combined manipulative and serological sources of error are calculated at 1 in 43,000, would be helpful

Two mistakes of this nature, picked up on cross-match, might represent a total of four such errors in the series, since bottles wrongly labelled O would escape detection by this final cross-matching check

Minor points, such as these, and the confusion in the description of the anti-U antibody (p 281) must not be allowed to detract from the value of this book The subsequent editions, which will assuredly be demanded, will provide opportunity for elucidation and correction

The bibliography is comprehensive and indicates the degree of care that has been taken in providing a manual which should appeal to pathologists, technicians and indeed to all engaged in blood transfusion work

R A ZEITLIN

SCIENCE AND THE HUMANITIES

History and Philosophy of Science

An Introduction By L W H Hull. Pp xi+340+16 plates (London and New York Longmans, Green and Co , Ltd , 1959) 25*s* net

“THIS is not a detailed history of science It tries to bridge the gap between science and the humanities by considering scientific ideas in a context of history and philosophy ” In these words the author describes the object of his work Few will deny the existence of the gap, or the need to bridge it, and a book of this nature should be welcomed, on one hand, by those whose training and background have led to an emphasis on technology, and on the other, by students of the humanities who seek to understand the vital contribution of science to human thought The general reader also will find the author's approach both interesting and stimulating , he anticipates the criticism that “most readers will, no doubt, find too little about some topics and too much about others” He points out that before the spread of evolutionary ideas the influence of biology seems scarcely comparable with that of mathematics and the physical sciences

The book opens with a review of ancient science covering three periods the first from the beginnings of science until the rise of Athens after the Persian wars , the second until the Macedonian conquests of the fourth century B C , the third period takes the Alexandrians as its theme This review is comprehensive in relation to the hundred pages allotted to it, and makes interesting and instructive reading Chapter 4 carries the story through the period of the Middle Ages, with some reference to Arabic contributions

In the two following chapters, celestial geometry and celestial mechanics are very adequately surveyed from the time of Copernicus to that of Newton With such fundamental changes in ideas concerning the universe, it is appropriate that a chapter is devoted to “Changes of Outlook and Method”, and this constitutes one of the most valuable parts of the book A separate chapter deals with other scientific developments in the sixteenth and seventeenth centuries, such as the phenomenon of light, and attention is directed to the philosophical thought of Berkeley and Hume

The chapter “The Nineteenth Century and Evolution' introduces the reader not only to Darwinian theory and its implications but also to its significance in the development of thought In an “Epilogue” which includes the theme of twentieth-century trends, the author gives a warning which it is to be hoped, in the interests of both science and the humanities, will not fall on deaf ears “It is urgently necessary to restore the unity of intellectual life Unless we do so, we shall soon lose what is best in Western civilization ”

H D ANTHONY

INDIAN PREHISTORY

The Pre-historic Background of Indian Culture

By D H Gordon (Sponsored by Bhulabhai Memorial Institute) Pp xi+199+32 plates (Bombay M D Desai, 1958 Distributed by N M Tripathi (Private), Ltd , 1958) Rs 20

UNTIL recent years the study of the archæology of the Indian peninsula has woefully lagged behind that of some other parts of the world Especially is this so in the case of its prehistory It is true that isolated finds of stone implements have been made from time to time during the past one hundred years—and in this connexion the name of Bruce Foote in Madras has an honoured place—but it is only recently that it has become possible to piece together an overall picture of the successive cultural phases in India, and even now the gaps in our knowledge are more than numerous The subject is complicated since India seldom presented a uniform picture Even in very early times the Madras area formed part of the vast Chelleo-Acheulean complex, while the northern regions belonged to another and distinct province which included the early stone-age cultures of Burma and south-east Asia. Most of the worthwhile investigations have, until recently, been undertaken by non-Indians, but nowadays highly trained investigators like Dr. Sankalia and his colleagues have come into the field and are making important explorations. But there is so much to be done in the field that there is little opportunity for these investigators to stand back, as it were, and give a general report of what has so far been pieced together of the ancient history of their fascinating land. It is here that Colonel Gordon steps in.

Gordon has served, travelled and explored in India for thirty-two years and himself has undertaken not a few investigations, and he knows as much about the rock-shelter paintings of the Central Provinces as any man alive. But in the volume under review he has set himself the task of attempting to see the archæology of India as a whole and to make available for students the latest ideas on the subject. Geographically, India is a large and varied country, and just as the cultures are not, and never have been, uniform throughout, so the climate differs in different areas and has differed greatly in past ages. A brief study of climate changes must necessarily be considered first, and then the earliest stone age cultures can come under review. The later stone age cultures are next dealt with, and here it must not be forgotten that in some regions these seem to have continued until quite a late date; indeed some of the Megalithic tombs and polished stone axes have been dated as late as the third century B.C. A chapter on the peasant potters of Makran, Baluchistan and Sind follows, and this naturally leads on to a discussion of the civilization of the Indus valley. Thanks to Sir John Marshall's work and the excavations at Mohenjo-Daro and other sites, a great deal has come to light of recent years, and this fascinating civilization has become comparatively well known. The period of invasions and the rock paintings and engravings are then dealt with, and in conclusion there are chapters on the 'Dark Age' stone and copper cultures, leading to a chapter which carries on the story to the threshold of history and to the use of iron.

Colonel Gordon has done his job well. It must not be expected that in one small volume the student will find detailed studies of the archæology of the whole of India. But the selections made are judicious and the result does give a connected picture of the past. There are a number of full-page illustrations at the end of the volume and plenty of maps, tables and text figures.

M. C. BURKITT

FLUID SYSTEMS

Chemical Engineering Practice.
Edited by Herbert W. Cremer and Trefor Davies. Vol. 6: Fluid Systems II. Pp. vii + 600 + xx. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 95s.; 13.30 dollars.

THE latest volume in this series covers a very wide range of chemical engineering operations, although for convenience the editors have labelled the volume "Fluid Systems II". There are fifteen chapters covering gas absorption, fluidization, liquefaction and fractionation of gases, adsorption, leaching, crystallization, colloids, filtration, sublimation and the practice of evaporation. Dr. Norman and his colleagues from Manchester have written two chapters on the principles of gas absorption and the characteristics of packed-column absorption towers. The first chapter is excellent, not only for those in universities and technical colleges but also for all who are concerned with gas absorption. The second chapter, though good, lacks a little of the practical touch one would have liked. The chapter on evaporation practice by Mr. Watkins from King's College, London, assisted by Mr. Macmurray from Scott and Son and Mr. Forker from the Dupont Company, is very readable and covers the usual types of units. More attention might have been given to the actual size of units and some of the practical problems associated with operating evaporators would have been appreciated.

The chapters on fluidization by Dr. Botterell from Birmingham and Mr. Turner from British Petroleum are excellent, and will be looked at very much as indicating the position with this relatively new technique, which offers so much promise of further development. In the same way the chapters by Dr. Gardner of British Oxygen Co., Ltd., and by Mr. Pasteur of J. and E. Hall are welcomed as showing the real problems and successes of low-temperature technology. Low-temperature gas separation is still a new technique but most challenging as a technical process.

Prof. Donald has given an interesting account of leaching, including one or two references to history which are lacking from the other chapters. One is left with the idea that operations of such long standing are not yet carried out with very elegant equipment and there must be room for improvement here. The chapter on the principles of filtration is also written by Prof. Donald.

Dr. Mullin from University College, London, has written the chapters on crystallization, centrifuges, and colloid science. These are all difficult subjects and one would certainly have liked more on the practical difficulties of continuous crystallizers. We cannot learn from these chapters the physical size of units for definite capacities and there are many unresolved problems in the production of true regular crystals.

Mr. Salter, from Dorr-Oliver, and Mr. Hosking, from L. A. Mitchell, have given a clear statement of the variety of filters and the method of selection of equipment. Their section on accessories such as pumps and blowers for vacuum filters is a real attempt to size up these important auxiliaries. One cannot help feeling that some of these units have had their day and are a bit crude; some pruning of variety might have been suggested by these specialized authors.

This book enables one to see the range of processing problems which are now regarded as the province of the chemical engineer. It is not surprising that in his relatively short history there are many untidy edges to his work. Apart from selecting the right type of unit there is a definite degree of uncertainty as to the ability of the engineer to scale-up such plant satisfactorily.

The book will be welcomed particularly as it provides a discussion of the work in quite a number of fields which have not been adequately covered before in the British literature.

Mr. Cremer has written a foreword to the volume in which he refers to the untimely death of the former managing editor, Mr. Trevor Davies. Mr. S. B. Watkins, head of the Chemical Engineering Department at King's College, London, has taken up the work.

J. M. COULSON

Basic Electricity

(A Course of Training Developed for the United States Navy by Van Valkenburgh, Nooger and Neville, Inc Adapted to British and Commonwealth Usage by a Special Electronics Training Investigation Team of the Royal Electrical and Mechanical Engineers) Part 1 Pp vi+127 Part 2 Pp vi+121 Part 3 Pp vi+122 Part 4 Pp vi+104 Part 5 Pp vi+117 (New York The Brolet Press, London Technical Press, Ltd, 1959.) 12*s* 6*d* net per part, 55*s* net the set

THIS five-part course, aimed at training technicians rather than electrical engineers, is distinguished by the simple language of its text and its concentration on essentials It is illustrated to an extent that makes it (or at least the first two parts of it) qualify as a visual aid as well as a text-book The cartoon-like artistry is a little florid—the sort of thing one might associate with "Jane" but not with "Fighting Ships", and the going seems slow, by ordinary teaching standards, in the early stages It soon becomes evident what the authors are up to—using the same technique as the creators of the Li'l Abners and the purveyors of branded goods, to set up an image and attract a loyalty to it, the image being that of the electron I have no doubt that the early parts would be highly successful in bringing people who would not normally gain a great deal from the printed word to a really sound understanding of the fundamental principles, and simple circuits and meters The last three parts use the artist in a much more quantitative kind of way The usual work on alternating current, a c circuits, and electrical machinery is done with the minimum of algebra, but every important result is explained and illustrated with the help of vector diagrams and graphs These parts, in fact, are a very well-conceived text-book of the orthodox type, and contain some new ideas for expounding the more difficult points, which are never shirked Instructions for experiments are given, with a list of apparatus needed to work through them The really exacting part of instruction at this level is in making the initial contact with the pupil The originality and skill that have been lavished on the early stages of the course should ensure for it a very high contact potential G R NOAKES

The Strategy of Chemotherapy

Eighth Symposium of the Society for General Microbiology, held at the Royal Institution, London, April, 1958 Edited by S T Cowan and E Rowatt. Pp ix+360 (Cambridge At the University Press, 1958 Published for the Society for General Microbiology) 35*s* net

THIS symposium shows what a complex field of research has developed from Ehrlich's pioneer work on the use of specific substances to attack micro-organisms in the tissues without damage to the host The organizer invited contributors to suggest fresh methods of attack and the result was a series of papers of extreme diversity in approach, techniques and objectives They were given by the microbiologist, the pharmacologist, the biochemist and physical chemist, and include such fundamental conceptions as membrane penetration, bacterial cell-wall synthesis and energy-supplying reactions, wherein the research worker is endeavouring to discover some subtle difference in the components of host and parasite which may be exploited to the detriment of the latter At the other end of the scale are the frankly empirical mass methods used so successfully in the production of the antibiotics and other synthetic drugs, but without any fundamental explanation These random methods still offer probably the greatest chance for further production of new compounds and therefore have their place in the field of chemotherapy, but the symposium does emphasize the necessity for the combined operations of each type of research worker if chemotherapy is to have a logical basis of development and not be, as one worker defined it, dependent upon intelligent guesswork H BERRY

The Native Pinewoods of Scotland

By Prof H M Steven and A Carlisle Pp xvi+368+20 plates (Edinburgh and London Oliver and Boyd, Ltd, 1959) 63*s* net

THIS beautifully produced book will be a welcome occupant of the bookshelves of many students of Scottish history and natural history The subject-matter is both broader and narrower than the title might suggest—broader in so far as the authors discuss much relating to the general history of Scottish forests and to the relationships of pinewoods to woodland of other species, narrower in so far as some features of the pinewoods receive particularly detailed treatment

The authors trace the history of Scottish woodlands from the Pleistocene period onward through historic times, collating and summarizing an immense amount of evidence from geological, palynological and archæological sources which has never before been brought together They pass on via a very general ecological account of the pinewoods to a systematic description of all the known surviving examples of woods which are with reasonable certainty composed of naturally regenerated indigenous pine Carefully prepared maps accompany the descriptions, and show the exact distribution of pine and of other species of trees in the neighbourhood of the pinewoods This portion of the book is noteworthy for copious historical information which has been gathered together from estate records, early maps, accounts by travellers, etc An account of Dr Carlisle's study of the morphological variation of pine in Scotland concludes the book

A fine series of photographs illustrate the book I have noticed only one trivial misprint The book should form a valuable foundation for further ecological work in our western outposts of the European boreal conifer forest, which have so long attracted British naturalists E W JONES

South African Animal Life

Results of the Lund University Expedition in 1950–1951, Vol 5 Edited by Bertil Hanström, Per Brinck and Gustaf Rudebeck Pp 520 (Stockholm Almqvist and Wiksell, 1958) 75 Sw kr

VOLUME 5 of this series of publications contains accounts on Porifera, Crustacea, Diplopoda, Diptera, Hemiptera and Coleoptera Six chapters each on the Hemiptera and Coleoptera make up the bulk of this volume As in earlier volumes the taxonomic treatment is amplified by zoogeographical accounts, and frequently the general accounts are not restricted to the description of the Lund collections, but bring them into relationship with other material For an assessment of the scope and general merit of this series the reader is referred to an earlier article in this journal (*Nature*, 180, 56, 1957)

Inside the Living Cell

Some Secrets of Life By Dr J A V Butler Pp 174+16 plates (London George Allen and Unwin, Ltd , 1959) 21*s* net

DR J A V BUTLER'S former book, "Man is a Microcosm", was reviewed enthusiastically in these pages some years ago The scope of the present work is much wider, quite apart from the fact that many parts of the subject have advanced radically in the past few years

The author describes in straightforward language many of the great advances which have been made during the past ten years in our knowledge of the mechanisms which operate within living cells These include not only the ways in which food materials are taken and transformed into proteins, nucleic acids and other constituents, but also the way in which the ability to make all these is transmitted from generation to generation In these processes we come very near to the basic mechanisms of life itself In addition to his excellent account of the normal behaviour of cells the author discusses neoplasms and other abnormalities caused by ionizing radiations, those which seem to occur spontaneously and those which are caused by chemical carcinogens

Later in the book some abilities of specialized cells, such as those which form muscles and nerves, are dealt with, and an account is given of the immense structures which living cells achieve in the higher animals and finally in man

Altogether the reader is given some idea of what life has achieved, first, in reaching the level of the cell, and secondly, in elaborating great assemblies of cells in the higher forms of life Finally, the author discusses the causes and significances of ageing and death, and the meaning of life in the world of atoms

Throughout, the work is informed by the original work and thought of the author The book is beautifully produced in every way The illustrations are particularly good and include photomicrographs such as those by D A Sholl of nerve cells in the visual cortex, and by R W G Wyckoff of bacteriophage The book can be recommended warmly to many classes of reader Most of it should appeal to the educated adult and it will be invaluable for the general reading of a good science sixth former, or university undergraduate W L SUMNER

Organic Syntheses

An Annual publication of Satisfactory Methods for the Preparation of Organic Chemicals, Vol 37, 1957 Edited by James Cason Pp vii + 109 Vol 38, 1958 Edited by John C Sheehan Pp vii + 120 (New York John Wiley and Sons, Inc , London Chapman and Hall, Ltd) Each 32*s* net

AMONG the 32 compounds for which preparative methods are described in Vol 37 are benzofurazan oxide, *trans*-2-dodecenoic acid,, glutaric acid and glutarimide, norbornylene, parabanic acid, and *ar*-tetrahydro-α-naphthol , and the 31 preparations of Vol 38 include diphenylacetaldehyde, hendecanedioic acid and several related compounds, monobenzal- and monobromo-pentaerythritol, monovinylacetylene, *trans*-stilbene oxide, and 2-vinylthiophen Each volume has a cumulative index extending back to Vol 30 Four enclosed leaflets direct attention to explosions that have been experienced in preparing ethyl azodicarboxylate, methoxyacetylene, and *o*-toluamide, and in storing *p*-tolylsulphonylmethylnitrosamide JOHN READ

Trends in Birth Rates in the United States since 1870

By Bernard Okun (The Johns Hopkins University Studies in Historical and Political Science, Series 76, No 1) Pp 203 (Baltimore, Md The Johns Hopkins Press , London · Oxford University Press, 1958) 3 50 dollars , 28*s*

THIS monograph consists of three essays The first two discuss the secular trend of the declining birth-rate in the White and Negro population of the United States, respectively The method used is an analysis of fertility indices (the ratio of children to the total population, and the ratio of children to women of reproductive age) in different States of the U S A The discussion will be of interest mainly to the specialist in demography, and adds little to what is already available in the monograph by Grabill, Kiser and Whelpton, who have surveyed the material in much greater detail The third essay, however, is of more general interest Here Dr Okun surveys the hypotheses and approaches used in explaining birth-rate trends, and attempts a classification and an assessment of the methods that can be used to test the hypotheses No very definite conclusions emerge, but the essay is a useful summary

The Structure of Glass

Proceedings of a Conference held at Leningrad, November 23–27, 1953 Translated from the Russian by E B Uvaroc Pp ii+295 (New York Consultants Bureau, Inc , 1958) 20 dollars

THIS translation was sponsored by the Glass Division of the American Ceramic Society and the National Science Foundation with the expressed object of providing a general look at the status of glass science in the U S S R , and admirably does it fulfil its purpose The fact that this conference was attended by more than 500 delegates from twenty-eight towns of the Soviet Union is itself impressive, and conveys immediately an idea of the large scale on which research in this field is being conducted

As a report of a conference the volume is excellent , the printed discussion is particularly lively, and occupies 70 pages , 42 papers were communicated to the conference and these account for 228 pages of the volume Remembering that the conference took place five years ago it would appear that at that time there was no great difference between the topics being discussed in the U S S R and in Western circles

It would be easy to dismiss the discussion as being concerned too much with semantics and to criticize some of the ideas put forward However, examples of similar ideas and arguments are well sprinkled through the literature The great argument of the conference was on the rival merits of the 'random network' theory of glass structure and the 'crystallite' theory The proponents of the crystallite theory attacked their opponents on the ground that the randomness was not complete, while their own definition of 'crystallite' was hedged by sufficient qualifications to make it clear that the majority of them did not mean that term to imply anything that could properly be described as a crystal

Perhaps the fairest summing-up is that here there is realization that the network theory of glass is only a first approximation—a view which is receiving increasing emphasis at the present time

The translation was well worth while, and all interested in the physics and chemistry of glasses will enjoy reading the book R W DOUGLAS

LIBERTY IN AN AGE OF SCIENCE*

By Sir SOLLY ZUCKERMAN, C.B., F.R.S.

Department of Anatomy, University of Birmingham Medical School, Birmingham

IF, two or three decades ago, one had spoken of science and liberty in the same breath, the emphasis would have been different from my present theme. That period was the era in which the social function of science was a central issue of debate, and it culminated in the almost total mobilization of the scientific forces of our two countries during the Second World War. This War was the turning point. Where previously scientists were seen, according to the interests of the observer, either as dedicated scholars, or as the source of invention, or as the technical guardians of the social services on which an urban civilization depends, to-day they also appear in a number of new guises—as the backbone of national defence; as pioneers of outer space; and even as the counsellors of presidents and prime ministers.

The world has come not only to recognize but also to insist that science has a social function; but, not all the world. There have always been those who have questioned whether the democratic way of life, and a life of liberty, can survive the stresses of rapid economic growth; and as the hazards of our century mount, their numbers are being reinforced by others who are fearful lest all society becomes a victim of the forces that have been unleashed in our present scientific age. "The scientists think they are God," one exclaims; "they want to remake the universe; and we pay the price for their mad ambition."

This is no lonely voice, and it is one that has been heard before. Long before the days of artificial Earth satellites, long before the era of nuclear weapons, George Gissing wrote: "I hate and fear science because of my conviction that for a long time to come, if not for ever, it will be the remorseless enemy of mankind; . . . I see it bringing a time of vast conflicts, which will pale into insignificance the thousand wars of old and, as likely as not, will overwhelm all the laborious advances of mankind in blood-drenched chaos."

But what science is this that is the enemy of mankind? Surely not the pure thought or theory which enhances man's understanding? It is well to consider out of what confusion it is that science presents this ominous look.

The cultivation of science, by which we mean the quest for new natural knowledge through controlled and reproducible observation, can be treated as an endeavour which is either personal and private, or social and public. But however pure or personal may be the object of acquiring a scientific understanding of the universe in which we have our being, science inevitably becomes social or public not only because there can be no awareness of the existence of a new scientific idea until it is communicated from one person to another, but also because pure science frequently turns out to be basic to some practical development—to some piece of applied science—or to some convention of thought, which then starts transforming the environment within which it was distilled. So it is that pure science and applied science have progressed hand-in-hand over the years, the pure fertilizing the applied with ideas, and the applied often providing the pure with the physical apparatus to help in the next intellectual leap forward.

This process has been a major factor in the progressive replacement of superstition by rational theory. And as Condorcet—that great French scientist of the latter half of the eighteenth century who was so powerful a protagonist of human dignity and freedom—wrote: "The progress of the sciences ensures the progress of the art of education which in turn advances that of the sciences"—a reciprocal operation which he did not exaggerate by describing "as one of the most powerful and active causes working for the perfection of mankind".

Man's evolution has also meant the continuous transformation of his social institutions through the directed application of pure scientific knowledge. We talk to-day of living in a new age of science, of a world in the throes of a new scientific revolution; but there is nothing new about this revolution except its speed and its greater hazards. Science has always revolutionized society, ever since some basic discoveries in animal husbandry and crop cultivation made it possible for nomadic life to give way—ten to twenty thousand years ago—to permanent village settlements, and so to the diversification of labour and the beginning of trade.

The transformation of society by scientific discovery and application has continued ever since, sometimes so slowly that decades pass before the historical record reveals much change, sometimes as at present, with ever-mounting force. While it could be argued that the technical advances of the past ten to twenty years transcend those of the rest of human history; that the speed with which new discoveries are disseminated and applied is now unprecedented; that the political and economic consequences of all this scientific activity will prove far more profound than those which resulted from past epochs of discovery; there is nevertheless no immediate reason to suppose that the social process which is involved in to-day's scientific revolution is different in kind from what was entailed in previous phases of rapid change.

If we are to understand the confused position in which the layman and the scientist now stand in relation to each other, we need therefore to examine certain features which characterize the growth of scientific knowledge, and also some which relate to its present impact on social affairs.

What, first, do we mean by the need for academic freedom as it applies to the pure scientist? One means not only the freedom to investigate those problems which one seeks oneself, but also the fact that significant advances in scientific knowledge cannot be ordered by decree. Every act of creation requires its special freedom. While our theories of thermodynamics, of relativity, or of natural selection, undoubtedly had their antecedent relations, no one could have predicted, before it actually occurred, if, and how, and when any of these major advances in our scientific understanding was to have taken place Nor would it be possible to force a scientist to make this or that specified discovery For example, genius though he was, no one could have prevailed upon Charles Darwin, say, in 1830 when he was twenty years old, to anticipate the basic genetic law revealed by Gregor Mendel thirty-five years later One can employ special measures to encourage this or that branch of science One can provide the conditions in which pure science flourishes, by multiplying the opportunities which make it possible—the universities, the laboratories, the freedom from other responsibilities But having done these things, one can only then wait to see what emerges One cannot in advance specify the shape and content, or determine the possible impact of what is not yet known.

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* Substance of the address delivered at the Sixty-fifth Commencement Exercises of the California Institute of Technology on June 12.

Being unpredictable, it follows that the untrammelled emergence of new scientific ideas is not compatible with any restraint on the liberty of the scientist to roam where his fancy leads Indeed, once the growth of any set of scientific ideas becomes constrained, it stands in danger of becoming obstructive dogma A valid scientific hypothesis is never more than the best statement which, for the moment, can be made of the relations of the matters to which it refers, and should be swept away as soon as a better one emerges

The growth of science thus necessitates freedom, even the freedom to be revolutionary How then is stability to be achieved in a world in which science has so great an impact ? How does science become, as it has often been described, the servant and the handmaiden of freedom ?

One's immediate answer is that since economic and military power are to-day proportional to the degree with which scientific knowledge is exploited, science is the defender of the ideal of freedom on which Western democracy rests In a more particular sense, as many have pointed out before, the applications of science have also provided the apparatus which has made central government powerful

But surely science is in these respects no more the servant of the democracies than of the authoritarian regimes poised against them, and of the philosophical and political concepts on which they, in turn, are based In a world of conflicting power, science is both the arsenal and instrument of power—but science *qua* science is always a neutral arsenal and a neutral instrument

We cannot invest pure scientific knowledge with any inherent moral direction That is imparted by the way science is used, and we can be certain, therefore, that all sides in the present world struggle will use science and technology in the achievement of their respective national aims , and also in whatever efforts they may make to narrow the ever-widening gap between the developed and under-developed territories of the world

My first main point, therefore, is that while the growth of fundamental scientific knowledge necessitates complete freedom from restraint, science is not uniquely associated with the preservation of freedom either in the personal or social sphere

But there is a deeper issue underlying the relation of science and freedom Let me first define the sense that I propose attaching to the concept of freedom or liberty, which both in isolation, and as the ideal which animates democracy, has always been a major concern of philosophical discussion

By freedom I mean here the liberty an individual enjoys after the infinite number of degrees of freedom which are open to him in the abstract have been reduced by, say, the give-and-take of social life, still leaving a vast area of choice within which he could either engage in, or desist from, any particular activity It was essentially in this sense that the great utilitarians of the industrial revolution—Bentham, John Stuart Mill and others who joined them in the battle for justice—conceived of freedom in the ideal society—a society which is governed by common consent for the common good , in which the greatest number enjoy the greatest happiness , in which there is equality of suffrage, and in theory, at least, in educational and economic opportunity , and in which laws and institutions, regulating the behaviour of individuals, are there because the unlimited exercise of one man's liberty would inevitably impose restrictions on that of his fellows

It is essentially in this social sense, however 'negative' it may be, that liberty is implied in the proposition that science is its handmaiden Science may, of course, well be the handmaiden of equality in the economic sphere, given, of course, the right political institutions But is the proposition true in the philosophical sense of the term 'liberty', whether in relation to the concept to which I am directing my observations or to any other idea of liberty which philosophers have examined ? Can it be true of the actual environment within which we exercise our freedom—an environment which is not some unreal stratosphere peopled either by abstract shadows of human beings or of social groups ? Surely our social environment is a real one which is constantly being transformed by new scientific ideas, and by the application and practical development of these ideas This transformation constitutes more than a process whereby men are conditioned in their thoughts and actions Whenever some major development is pursued, for example, the development of machines based on steam, it means that some other path that potentially might have been followed was not followed A material civilization of motor-cars, of radio, of synthetic fibres, of nuclear power is not necessarily the only form a material civilization might have taken But now that it has taken that shape, it helps define for us the content and boundaries of the area within which we exercise our freedom

Liberty, in the sense I am using the term (and I believe to most political philosophers), means the power to act freely within the compass of the institutions which a people may set up in the exercise of their sovereign power, which implies their right to act as they think best as a collective body and which, according to legal theory, "is not restrained in any way except by the limitations inherent in human nature" It is irrelevant here that the exercise of democracy may not infrequently depart from its ideals , or that the institutions which had to be set up to preserve the hard-won freedom of modern times may themselves have eroded the principles they were meant to preserve The point I wish to make is that science, through its practical impact, is to an increasing extent, almost to a dominant extent, determining the way the presumedly uninhibited sovereign power expresses itself Because of its achievements in eliminating disease and alleviating pain, through the food and wealth it has brought, most people to-day prefer to regulate their lives in accordance with scientific discovery rather than in any other way In that sense they are prepared to constrain their abstract liberties in accordance with what science unfolds, and the riches it brings Is the choice, we may ask, conscious ? Can we know for what it is we are opting ? Hobbes, like other philosophers, found liberty consistent with necessity Is liberty truly consistent with necessity, when necessity is determined by science ? Is the sovereign power consciously deciding to develop this or that scientific discovery, and so to determine social development in this or that direction ? Or is it merely adapting itself as best it can to what comes out of Pandora's scientific box ?

The answer to any of these questions is inevitably bound up both with the constraints and unpredictability of any new major scientific advance Of course, there are always certain fields of science which are more popular and better supported than others Scientific knowledge never develops evenly over the whole potential field of knowledge But in so far as scientific activity is in general confined by past discovery to certain areas, so is our abstract liberty, in effect, constrained Furthermore, in any field of science, several alternative courses of action might be pursued in search for a solution to a problem In choosing any one of them, the research worker may deny himself, and others, the opportunity of pursuing another There is also the increasing complexity of the scientific knowledge which is now being transformed into new remedies, new chemicals, weapons-systems, and so on The facts which these days transform our lives become more and more difficult to comprehend, and on occasion are still not fully decided when they are applied If this were not so, would there still be debate—I choose the most urgent example of all—about the hazards associated with radioactive fall-out ?

Above all is the fact that the nature and magnitude of potential discovery cannot be defined in advance , any more than can its impact on our social lives As de Tocqueville wrote "We entrust ourselves to the future, an enlightened and impartial judge—but one who sits, alas, always too late "

Faraday, Hertz, Curie—what could they have known of the ultimate uses to which their discoveries would be put in the field of electric power, radio and nuclear energy , or of the social and political consequences of their uses We ourselves, years later, cannot tell what these consequences will be Can we, to refer to just one more vital question out of many new ones this scientific age is generating, commit ourselves now to more than arbitrary views of the possible political consequences of the elimination of disease and of its complementary change, the explosive growth of population in so many areas of the globe ?

Science has created wealth , it has helped in the struggle for freedom from economic exploitation , it has redistributed power But in doing these things, as it widens the area of material choice, it circumscribes and determines the environment in which we exercise our abstract liberties That is my second point Itself demanding freedom, and revolutionary in its ways, science is now determining, in an increasingly unpredictable way, the main issues about which we, as citizens, exercise our freedom of choice Can there be much more than a fictional verity to the abstract idea that an area exists within which men can enjoy the capacity of unconditioned or untrammelled choice ?

Democracy was man's answer to tyranny and exploitation The only form of exploitation it will never help overcome is the coercion of new knowledge, which by guiding our social lives into certain channels, limits advance in other directions , the new knowledge which focuses the interests of humanity on goals which cannot be properly charted until they have been achieved To the philosopher, as I have said, ultimate limitations on the freedom of the individual are set by the inexorable laws of Nature To the scientist, the limitations are set by the particular laws of Nature man himself discovers, out of a potential infinity of such laws, and from the use to which he puts these laws

Up to now we have been able to claim that the applications of science have increased the sum total of human happiness But to-day we stand at a cross-road The process of applying scientific knowledge is as endless as is the prospect of gathering new knowledge, and the basic scientist is responsible for only the beginning of the cycle of activity which creates a demand for the application of his discoveries Industrialization has established itself as the one sure cure for poverty in a world the bulk of the population of which still lives by subsistence farming , and history as yet gives no example of any but small communities which have voluntarily turned their backs on higher material standards of living Instead, a uniformity of desire and demand is generated for the so-called good things of life as the one world discovers how the other lives, and what it itself lacks Obviously we cannot say that the economic history of the West will be recapitulated as industrialization spreads, and as the chains of the past are broken in distant parts of the world But we can be all but certain that neither the needy nor the rich will allow the process of applying the fruits of scientific knowledge to stop, either in the national or the international frame In this process means become ends, because as new ways of doing things are discovered, they transform the things being done, and so their purpose In these days it is only in theory that one chooses weapons and tactics to achieve a strategy In fact, weapons often end by determining strategy—and sometimes the purpose behind the strategy

In my view it is against this force of scientific application that the Gissings of to-day rail—not against science as such , and it is this force which could constrain our democratic liberties, and which, if we ceased being vigilant, could even constrain the liberty of pure and basic science—and by so doing paradoxically destroy itself

Ideally we think that democracy to-day means government by the representatives of the people by consent of the people But many to-day also feel that the sovereign power, the people, has through a process of negative democracy, abrogated its rights to a power-*élite*, to a bureaucracy, to what-you-will, which is consciously determining the directions we follow This, it seems to me, is again too simple The element of the unknown in government increases with every step we are now taking to apply the fruits of science If sovereign power is being abrogated, it is less to some governing body, however formed , and more and more to a process of applying scientific knowledge without any real possibility of determining its final consequences Neither the voice of the majority, nor those through which it is expressed, can proclaim the precise lines of the future

Where do scientists stand, as ordinary citizens, in this process whereby the application of the fruits of their discoveries can become a potential prison for our abstract liberties? It is argued that because of their special knowledge scientists can be aware of the danger and promise arising from their discoveries, and that therefore they have a special responsibility in relation to the most pressing problems of our time. I should agree with this, if it meant no more than that scientists are better able to appreciate the scientific facts. For how can the scientist as such, who is not responsible for its application, accept the responsibility for predicting some vast social transformation that might result from what seems an innocent observation at the time it is made?

But I should agree all the more if one coupled with this view of the scientist's responsibility the thought that in the problem of preserving our liberties lies the most important reason for regarding an education in science as constituting to-day an essential part of an education in the humanities. For if an understanding of social and political purpose is one of the aims of the liberal arts, then that aim cannot be realized until their scope is widened to embrace a proper understanding of the scientific knowledge the application of which is now so rapidly transforming our intellectual and material environment.

Science, technology and humanism seem to have assumed that order of importance in the determination of our affairs. I do not know how it is in the United States, but over the post-war years the changes which the tacit application of science and technology have occasioned in Great Britain seem far more profound than any that have been brought about through the overt discussion of social values or social goals. If this kind of thing is happening, can the humanities continue as a potent educational discipline without encompassing an understanding of the social forces which derive from the application of the natural sciences? Scientific literacy, we are told in a recently issued report on education, will need to be far more widespread than it is "if we are to solve the problems of this age". Undoubtedly this is needed, but alone it is not a sufficient condition to ensure the solution of our problems—for here I agree with Aldous Huxley that "higher education is not necessarily a guarantee of higher virtue or higher political wisdom". What we most need to learn is that in the major scientific matters which now affect human destiny, one cannot safely take decisions for to-day unless we realize that those same decisions determine the future. This realization may not lead to the right decisions, but it might help obviate some of the worse.

SATELLITE OBSERVATIONS OF SOLAR COSMIC RAYS

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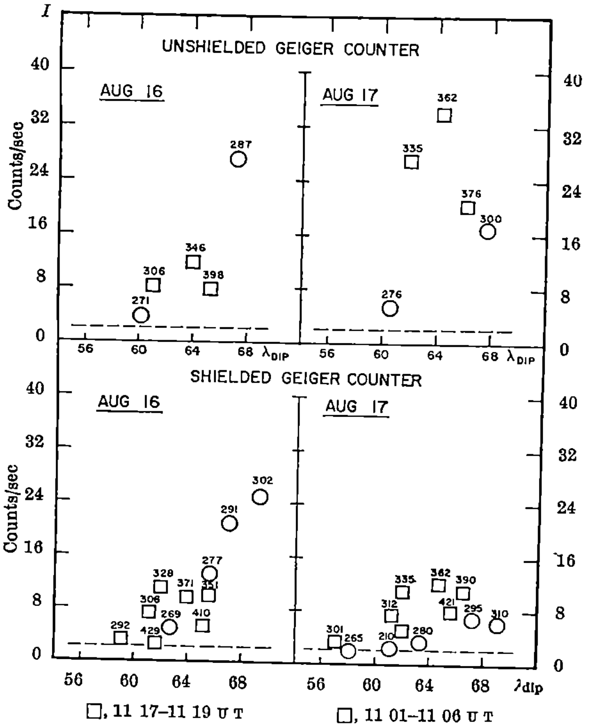
On three occasions during August 1958, large increases in the intensity of charged particles outside the Van Allen radiation zones were detected by the *Explorer IV* satellite 1958 epsilon, at high magnetic latitudes and rather low satellite altitudes (270–650 km.), where the Geiger tubes carried in the satellite normally count only cosmic rays. Figs. 1, 2 and 3 show that the charged particle intensity in both counters increased sharply with magnetic latitude, above about 60°, on August 16–17, August 23–24 and August 26–27. (We have defined 'magnetic latitude', λ_{dip} from the magnetic dip angle δ at the point of observation, through the dipole relation $2 \tan \lambda_{\text{dip}} = \tan \delta$.) Different symbols have been used for each satellite pass on any one day, recorded at the microlock station in Van Buren, Maine, in the geographical longitude range (95° W.–45° W.). The time-interval for each pass (usually about 5 min. duration) is given, and each point has been characterized by the altitude in kilometres at which the observation was made. The charged particle detectors in the satellite have been described in detail elsewhere by Van Allen *et al.*[1] The two Geiger counters (one shielded with 1.6 gm./cm.^{2} lead, and the other unshielded except by the satellite hull) could detect protons of energies greater than 40 MeV. and 30 MeV., respectively, and electrons of energies greater than about 5 MeV. and 3 MeV. The omnidirectional geometric factors ranged from 0.140 cm.^{2} to 0.823 cm.^{2} in the shielded counter, and from 0.140 cm.^{2} to 0.705 cm.^{2} in the unshielded counter. Table 1 gives the upper and lower limits to the omnidirectional fluxes of particles which would produce the highest observed counting rates in (*a*) the unshielded counter

Table 1

Date August 1958	Time of satellite pass (U.T.)	(*a*) Flux through unshielded Geiger counter (particles/cm.^{2}/sec.)	(*b*) Flux through shielded counter (particles/cm.^{2}/sec.)	(*c*) Ratio of counting rates unshielded/shielded	(*d*) $E_{\min}$ (MeV.)	(*e*) $E_{\max}$ (MeV.)	(*f*) Elapsed time after 3 + solar flares (hr.)
16	11.17–11.19	$86 > J_{0u} > 17$	$78 > J_{0s} > 13$	1.1 ± 0.3	~ 90	~ 200	6.8
16	13.11–13.15	$193 > J_{0u} > 38$	$179 > J_{0s} > 30$	1.1 ± 0.2	~ 60	~ 200	8.7
17	11.01–11.06	$240 > J_{0u} > 48$	$86 > J_{0s} > 14$	2.8 ± 0.3	~ 90	~ 200	30.5
17	12.56–13.00	$121 > J_{0u} > 24$	$43 > J_{0s} > 7$	2.8 ± 0.5	~ 60	~ 200	32.4
23	09.22–09.30	$577 > J_{0u} > 115$	$193 > J_{0s} > 33$	3.0 ± 0.2	~ 90	~ 250	19.1
23	11.14–11.23	$445 > J_{0u} > 88$	$150 > J_{0s} > 25$	2.9 ± 0.2	~ 35	~ 250	21.0
24	10.59–11.05	$140 > J_{0u} > 28$	$37 > J_{0s} > 6$	3.8 ± 0.5	~ 35	~ 250	43.8
26	08.26–08.34	$1{,}010 > J_{0u} > 200$	$465 > J_{0s} > 79$	2.2 ± 0.1	~ 85	~ 350	8.4
26	10.22–10.28	$1{,}300 > J_{0u} > 265$	$515 > J_{0s} > 88$	2.5 ± 0.1	~ 55	~ 350	10.3
27	08.06–08.15	$143 > J_{0u} > 28$	$46 > J_{0s} > 7$	3.1 ± 0.5	~ 85	—	32.0
27	10.04–10.08	$132 > J_{0u} > 26$	$50 > J_{0s} > 8$	2.6 ± 0.5	~ 55	~ 350	34.0

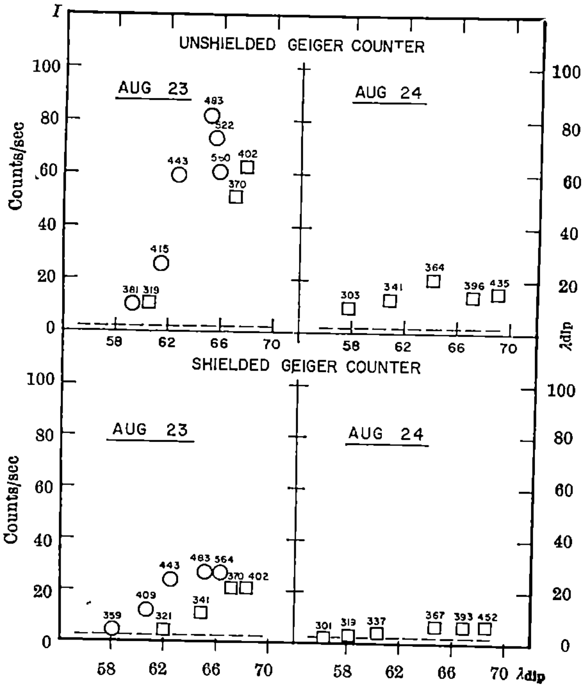
Intensity versus magnetic latitude
Altitude range 270–450 km



□, 11 17–11 19 U T
○, 13 11–13 15 U T
□, 11 01–11 06 U T
○, 12 56–13 00 U T
— — —, Cosmic ray counting-rate

Fig 1

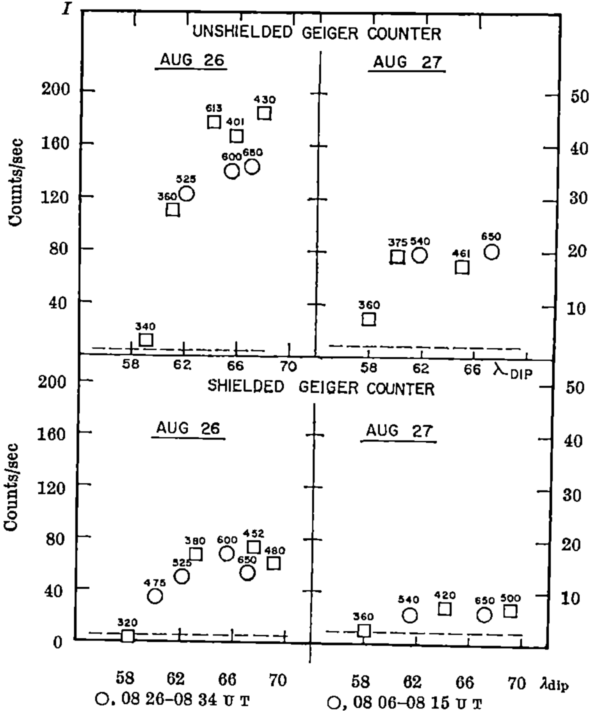
Intensity versus magnetic latitude
Altitude range 300–570 km



○, 09 22–09 30 U T
□, 11 17–11 23 U T
□, 10 59–11 05 U T
— — —, Cosmic ray counting-rate

Fig 2

Intensity versus magnetic latitude
Altitude range 300–650 km



○, 08 26–08 34 U T
□, 10 22–10 28 U T
○, 08 06–08 15 U T
□, 10 04–10 08 U T
— — —, Cosmic ray counting-rate

Fig 3

(J_{0u}), (*b*) the shielded counter (J_{0s}), and (*c*) the ratio of these counting rates (unshielded/shielded) at each satellite pass on which an increase in intensity was observed The cut-off energies for protons, at (*d*) the highest magnetic latitude on each pass ($E_{\min}$) and (*e*) the lowest latitude at which counting rates in excess of the cosmic ray rate were recorded ($E_{\max}$), are estimated from the local values of the Earth's magnetic field[2]

The particle fluxes are at least one or two orders of magnitude greater than the normal cosmic ray flux It seems unlikely that these intensity increases are due to soft particles from the outer Van Allen radiation zone, because

(*a*) *Explorer IV* cuts through the outer zone (as observed with the Geiger counters) at about 56° magnetic latitude, that is, farther south than the intensity increases reported here

(*b*) The ratio of counting rates between the unshielded and shielded Geiger counters in the outer zone is typically, about 30 or 40 to one, in contrast to the comparable counting rates observed in both counters at the higher latitudes

The ratios unshielded/shielded are reasonably consistent with the hypothesis that the charged particles are protons the energies of which lie between $E_{\min}$ and $E_{\max}$ The wide limits placed on the estimated fluxes are due to the uncertainty in the absolute geometric factor for the counters in the proton energy-range 30–100 MeV

We suggest that the intensity increases are in fact due to solar protons, associated with the large solar flares which occurred at 0432 U T on August 16, 1417 U T on August 22, and 0005 U T on August 26[3] Strong support for this suggestion is provided by measurements made from balloons and with riometers during this period

(1) Anderson[4] and Winckler *et al.*[5] measured an increase in charged particle intensity at balloon altitudes above Churchill, Canada (magnetic latitude 77°), and Fairbanks, Alaska (magnetic latitude 64°), on August 22 and 23, and have identified the particles as solar protons of energies up to a few hundred MeV. It is almost certain that the satellite has recorded the same event. (The increased intensity was not observed until August 23 because there was no pass over Van Buren after 1100 U.T. on August 22.) Anderson *et al.*[6] deduce a differential number energy spectrum $n(E)dE = K(t)E^{(-5 \pm 0.2)}dE$ (where t is the elapsed time after the solar flare) for the solar protons in the energy-range 100–400 MeV. At 1115 U.T. on August 23 they estimate that the flux of particles with energies greater than 100 MeV was about 1·5/cm.²/sec. Intensities observed from the satellite at that time suggest that a spectrum of this form may well extend down to about 30 MeV.

(2) Leinbach and Reid[7] have suggested recently that the absorption of cosmic radio noise, measured with riometers following large solar flares, is due to ionization of the upper atmosphere by solar protons. H. Leinbach (private communication) and Hultquist and Ortner[8] have observed three such events, commencing August 16, August 22 and August 26, in the riometers at Thule (Greenland), Fairbanks (Alaska) and Kiruna (Sweden). Absorption effects of this type occurred on twelve other occasions, between July 1, 1957, and September 30, 1958 (H. Leinbach, private communication).

During the period August 16–27 no increase in intensity was observed in the Canadian cosmic-ray neutron monitors at Resolute, Churchill, Sulphur Mountain and Deep River[9] at magnetic latitudes of 88°, 77°, 61° and 62°, respectively, but it is not surprising that protons with a steep number-energy spectrum and maximum energies of a few hundred MeV produced no detectable effects near sea-level.

The ratio of the maximum counting rates in the two counters increased significantly during each event. This suggests that either (*a*) the shape of the energy spectrum of the solar protons changes, and relatively more low-energy particles arrive at later times; or (*b*) that some particles with energies below the usual magnetic cut-off energy can arrive at a given location later in the event.

Freier *et al.*[10] have, in fact, reported that protons with energies below the usual measured cut-off were found at balloon altitudes over Minnesota on March 26, 1958, three days after a large solar flare, and at the time of a magnetic storm. When the Earth's field is disturbed, some charged particles can probably be admitted to regions normally 'forbidden' to them, and particles with energies below the normal cut-off may arrive at a given latitude during, and perhaps for some time after, the disturbance. During the period August 16–27 'sudden commencements' occurred at 0622 August 17, 0228 August 22, 0140 August 24, and 0303 August 27[11]. The lowest ratios unshielded/shielded occurred on August 16 before this period of magnetic activity.

There is now evidence from several sources which strongly suggests that solar protons with energies up to a few hundred MeV quite frequently bombard the upper atmosphere at high latitudes for some days following a large solar flare. The five widely observed, extraordinary increases in cosmic-ray intensity near sea-level which have occurred during the past twenty years of continuous observation are probably unusually energetic examples of a common solar phenomenon, namely, the acceleration and ejection of protons with energies approaching those of galactic cosmic-ray particles.

We should like to thank Prof. J. A. Van Allen and Dr. K. A. Anderson for many interesting discussions. This work has been assisted by the U.S. International Geophysical Year project 32.1 of the National Academy of Sciences, the U.S. Army Ordnance Department, the Office of Naval Research, and the Atomic Energy Commission.

[1] Van Allen, J. A., McIlwain, C., and Ludwig, G., *J. Geophys. Res.*, **64**, 271 (1959).

[2] Rothwell, P., *Phil. Mag.*, **3**, No. 33, 961 (1958).

[3] "Solar-Geophysical Data", National Bureau of Standards Publication C.R.P.L.—*F* 170 (1958).

[4] Anderson, K. A., *Phys. Rev. Letters*, **1**, 335 (1958).

[5] Winckler, J. R., Peterson, L. E., Hoffman, R., Arnoldy, R., and Anderson, K. A., *Bull. Amer. Phys. Soc.*, **4**, No. 4, 238 (1959).

[6] Anderson, K. A., Arnoldy, R., Hoffman, R., Peterson, L. E., and Winckler, J. R., *Bull. Amer. Phys. Soc.*, **4**, No. 4, 238 (1959).

[7] Leinbach, H., and Reid, G. C., *Phys. Rev. Letters*, **2**, 61 (1959).

[8] Hultquist, B., and Ortner, J., *Nature*, **183**, 1179 (1959).

[9] I.G.Y. cosmic ray data, supplied by National Research Council of Canada.

[10] Freier, P. S., Ney, E. P., and Winckler, J. R., *Bull. Amer. Phys. Soc.*, **4**, No. 4, 237 (1959).

[11] "Geomagnetic and Solar Data", *J. Geophys. Res.*, **83**, 831 (1958).

A BORE-HOLE TO THE EARTH'S MANTLE: AMSOC'S MOHOLE

By GORDON LILL and WILLARD BASCOM

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MAN'S knowledge of the interior of the Earth has been largely obtained by indirect methods, and although a great deal is now known about the qualities that subterranean materials must possess, numerous uncertainties remain. There is now a project under way, sponsored by the AMSOC Committee of the U.S. National Academy of Sciences to obtain corroborative evidence about the nature of the interior of the Earth by the direct method of drilling a hole completely through the oceanic crust to obtain samples of the mantle. Since the boundary between the crust and mantle is known as the 'Moho' (after Prof. A. Mohorovičić of Yugoslavia, who first described the seismic discontinuity there) it seemed reasonable to contract the project name to 'Mohole'.

The American Miscellaneous Society, founded in 1952 as a whimsical reproof of scientific societies which are sometimes too specific for their own good, uses its cable address, AMSOC, in the alphabetical world of Washington. It has no formal members, officers, by-laws or publications; and there is a bent towards geophysics.

On the subject of drilling through the crust of the Earth, however, the AMSOC group has been formally organized so that it can receive funds from the U S National Science Foundation The original members of the Committee were Gordon Lill (chairman), Prof Maurice Ewing, Dr William Heroy, Prof Harry Hess, Dr Harry Ladd, Dr Arthur Maxwell, Prof Walter Munk, Prof Roger Revelle, Dr William Rubey, Dr Joshua Tracey and Willard Bascom (technical director)

The Mohole project in more or less its present form was born at a breakfast at Prof Munk's house in California, at which he led the conversation on the need for a geophysical analogue for the space exploration programme The suggestion of Dr Frank Eastabrook, made in *Science* (October 1956) for the digging of a "Geophysical research shaft", had set forth the principal scientific advantages of direct sampling But AMSOC, unaware at the time of that suggestion, proposed a deep drilling project

The following September, in Toronto, at the meeting of the International Union of Geodesy and Geophysics, a resolution was passed "urging the nations of the world to study the feasibility and cost of an attempt to drill to the Mohorovičić discontinuity at a place where it approaches the surface" A hole 10–15 km deep on an oceanic island was suggested The sponsors were Harry Hess, Roger Revelle and T F Gaskell

The question of the structure and material of the interior of the Earth is a puzzle which has long challenged the mind of man In all major aspects the most acceptable present hypothesis holds together very well This is remarkable, for it requires that there be reasonable agreement between at least eight sub-sciences, all of which make indirect measurements Studies of astronomy, meteorites, volcanoes, geological structure, gravity, seismic waves, the magnetic field, and heat flow each contribute to the total knowledge

If one assumes that meteorites are the wreckage of a planet similar to the Earth and that the rocks spewed out by volcanoes (the seismic precursors of which begin well below the Mohorovičić discontinuity) contain samples of mantle material, then we already have samples of the deep rocks Moreover, Harry Hess believes that mantle rock actually outcrops (at St Paul's Rocks in the mid-Atlantic, in Japan and in California) Astronomical observations give the total mass, the average density and the moment of inertia of the Earth

But in the main, evidence about the interior of the Earth has come from earthquake waves By the combination of tedious computation and great skill, seismologists have worked out characteristics of the planet which keep within the limits set by the other evidence

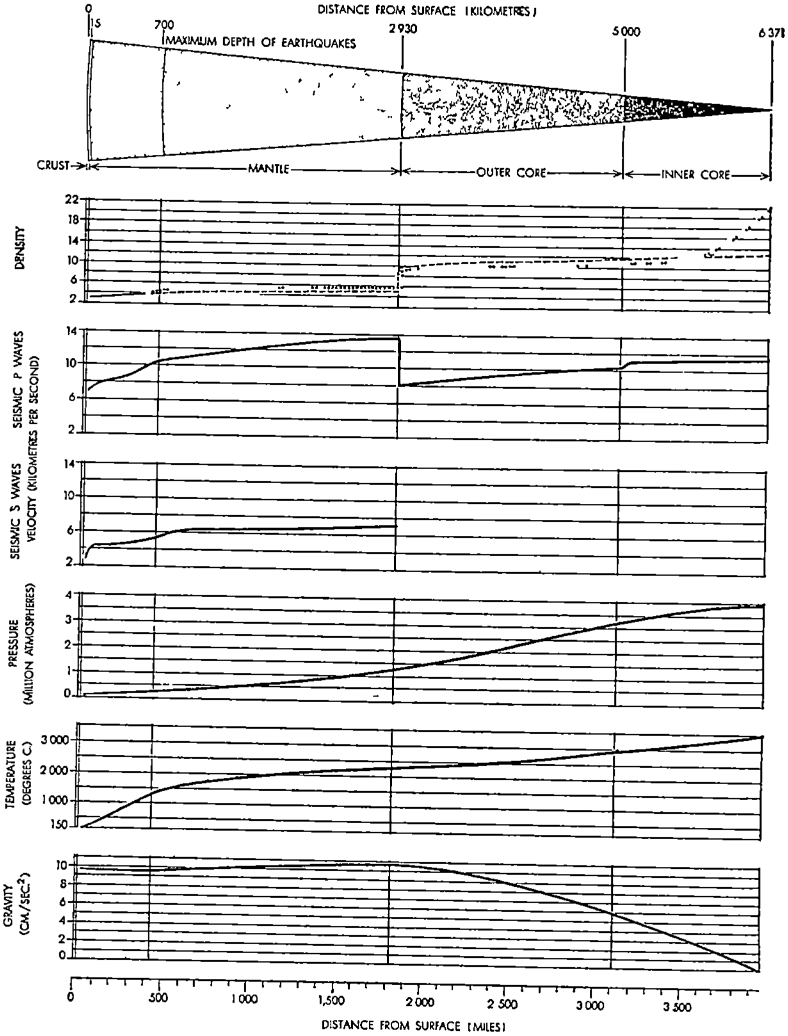

Fig 1 The interior of the Earth

The hypothesis of inner and outer cores surrounded by a thick mantle and capped with a thin crust has stood the tests of many years, now the problem is to refine the information and to obtain evidence which cannot come from further advances in seismology The composition of the mantle, which represents about 85 per cent of the volume of the Earth, is the principal problem of geophysics to-day, for although a lot is known about it, uncertainties remain (Fig 1)

The exact mineralogical and rock composition, the density, strength, temperature, the amount of radioactivity, the thermal and electrical conductivity—all these will contribute immeasurably to the understanding of the Earth and its origin Moreover, they will serve to enhance the value of the indirect geophysical measurements Finally, some new and entirely unexpected piece of evidence may be unearthed that will cause science to revise substantially its concept of the Earth

The crust is closer and easier to study than the interior, but even so it is more controversial Generally it is agreed that continents represent relatively thick blocks of andesitic rocks, and that ocean basins are composed of much thinner basaltic rocks—the average thicknesses being about 30 km.

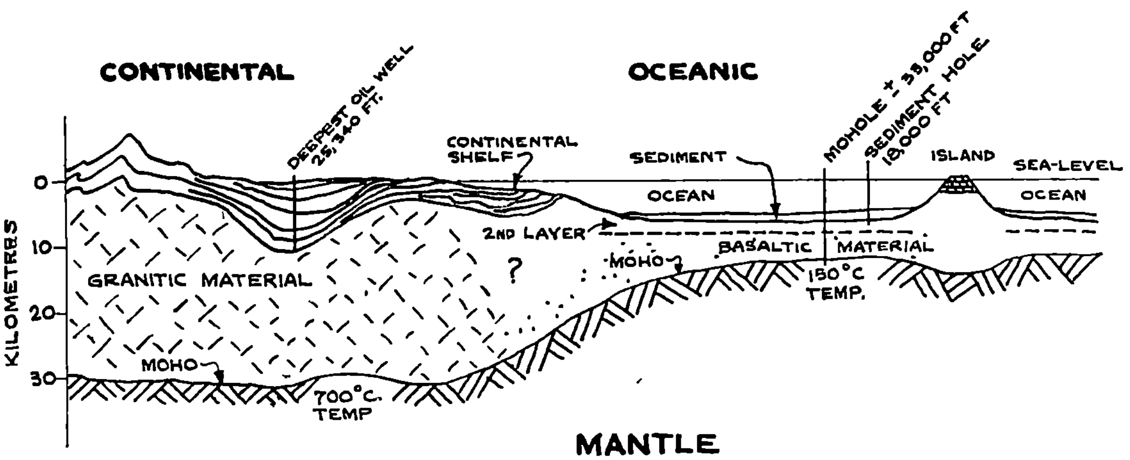

Fig 2 The crust of the Earth

and 10 km respectively The crust seems to act as though it is floating on viscous plastic mantle material, however, the response time is long, and certain anomalous areas not in isostatic equilibrium complicate the problem The Moho, which defines the boundary between crust and mantle, is recognized by an abrupt increase in the velocity of seismic waves—from about 7 0 km /sec to 8 2 km /sec

As the Earth developed, the water which reached its surface naturally ran downhill and covered the lower, thinner basaltic material, forming an ocean

The composition of the oceanic crust is studied by sea-going seismologists who use pairs of ships—one setting off explosions, the other listening In this way it has been discovered that beneath much of the ocean there are three main layers of material (1) the soft sediments, (2) the 'second layer', and (3) the 'third layer' (Fig 2)

The soft sediments of the deep sea floor (red clays and calcareous oozes) have been repeatedly sampled with corers which have penetrated as much as 20 m into the bottom and reached as far back as Cretaceous time

The seismic evidence suggests that the sediments are remarkably uniform in thickness, averaging about 0 4 km Unfortunately, this is much too thin to agree with the figure one gets by multiplying present sedimentation-rates by the supposed age of the oceans So one very large question to be answered is What happened to the rest of the sediments ? Moreover, it seems possible that the record of early evolution, missing on land, could be preserved in the lowest sediments

There are at least four theories about the composition of the 'second layer'—all of which begin with the knowledge that it conducts seismic waves at 4 5–5 5 km /sec It may be compacted sediments, basalt, dolomite or softer sediments screened by a layer of basalt, usually it is 1 or 2 km thick

The 'third layer' has a seismic velocity of about 6 5 km /sec, it is commonly called basalt but, as Hess points out, this is more a matter of 150 years of tradition than of evidence In fact, some scientists doubt that there are as many as three layers, others think there are more

One of the interfaces (possibly the Mohorovičić discontinuity) may represent the primordial surface of the Earth It may have a surface something like the face of the Moon to-day, it may be covered by a layer of meteoritic material or perhaps a conglomerate It may give evidence of our early atmosphere and ocean, or it may have been altered beyond recognition These speculations have served to make the proposed exploratory holes even more exciting

Many of these suggestions have been discussed and debated in the literature Harry Hess believes that the Mohorovičić discontinuity represents a frozen isotherm, J F Lovering thinks it represents a temperature–pressure relationship which has caused a phase change from an eclogite mantle to a basalt crust Tuzo Wilson believes that continental andesitic material must be rising from the mantle—from greater depths than the basalts He notes that K Sapper's figure of 0 8 km ^{3}/year over geological time would account for the volume of the continents, and that a slightly higher rate of volcanism in the early stages would allow for the emission of an oceanic crust as well Sir Harold Jeffreys believes that the ocean crust is too rigid to permit sideways motion of the continents, but recently there has been renewed interest in Wegener's continental drift theory There are points of disagreement on the distribution of radioactivity, on the interpretations of seismic velocities, and on the causes of oceanic trenches

The very fact that there is not agreement is a good reason for some direct exploration (if there were no controversy there might be even greater suspicion that something was wrong)

Some of these questions will be resolved if a continuous core of the various layers beneath the sea-floor can be brought into the laboratory for study and analysis In addition, in the hole from which the core is taken measurements can be made of temperature, heat-flow, the magnetic field, plastic deformation and seismic velocity

It is therefore the objective of the AMSOC Committee to see that a continuous, oriented core to the mantle is obtained and that the hole(s) are thoroughly instrumented Some of the instruments already exist, others will have to be developed or miniaturized to fit in the hole (which will be about 6 in in diameter at the bottom) No geologist or geophysicist doubts the value of such determinations, the question is How can it be done, and for how much money ?

In *Nature* of September 13, 1958, Dr Gaskell examined some of the technical problems of deep-hole drilling However, as the AMSOC feasibility study progresses, new objectives have been developed and

Table 1 Reach of Drill required to achieve Various Objectives

	Phase	Pacific						Atlantic	
		Clipperton Island area 10° 53′ N 105° 09′ W		Guadalupe Island area 28° 45′ N 117° 31′ W		Due south of San Diego, Cal 5° 47′ N 123° 59′ W		North of Puerto Rico 20° 40′ N 66° 30′ W	
		km	ft	km	ft	km	ft	km	ft
Depth of water	I	3 1	10,100	3 5	10,700	4 3	14,000	5 5	18,000
Depth to bottom of sediment		3 3	10,400	3 6	10,900	4 8	15,700	6 0	19,600
Depth to bottom of second layer		4 2	13,800	5 2	17,000	5 5	18,000	8 0	26,200
Depth to Mohorovičić discontinuity	II	8 6	28,100	10 8	35,500	9 7	31,800	9 6	31,500

Note Geophysicists think in kilometres, but drillers work in feet
Pacific data from R W Raitt, Scripps Institution of Oceanography
Atlantic data from J Worzel, G Sutton *et al*, Lamont Geological Observatory

new drilling technology has been disclosed so that now Gaskell's views need to be revised For example, the idea of drilling from an oceanic island has been abandoned because recent studies indicate that the mantle is as deep as 17 km under the islands that have been studied Developments in floating drilling platforms make it appear that deep-water drilling is feasible in any event, besides, we need the sedimentary results A review of the temperature situation suggests that temperatures in the mantle beneath the ocean crust will be less than 200° C At several sites where seismic work has been done, the total reach of the drill stem from the surface of the water to the mantle will need to be only 30,000 ft Thus as the project develops, the objectives seem more attainable with less difficulty and expense

Table 1 shows the length of drilling pipe required to reach the surface of the various layers beneath the sea-floor at four sites which are under consideration

Inspection of these figures shows that a drill reaching to 6 km (20,000 ft) will give results on the upper three layers Beneath that it is another 3–5 km to the Mohorovičić discontinuity For this reason the project will be divided into two phases The first of these involves the modification of existing equipment for drilling holes in the upper layers The second phase—which will take us on to the Mohorovičić discontinuity—will probably require a completely new engineering design, for the total length of the drill pipe must be well over a mile beyond that used in the deepest oil well to date (25,340 ft hole by Phillips Petroleum in western Texas)

The objectives of the first phase would be to obtain the best possible samples of the upper layers while testing out deep-water drilling methods For example, no one is sure how closely a ship must be held in position in deep water while it drills, but several schemes have been proposed which would probably keep it within a circle the diameter of which is less than 3 per cent of the depth (12,000 ft or so of water) The forces due to the drag of ocean currents on the drill pipe and casing are as yet unknown because of the lack of reliable deep-current data Questions of how often casing will have to be run and how it will be supported, of how well the soft sediments can be cored and if sea water is a satisfactory drilling fluid will be answered by the first test holes

There are four floating platforms which mount intermediate-depth oil rigs drilling in shallow water off the coast of the United States Many of the problems of ocean drilling have been ingeniously solved by these operators, so that only minor modifications of standard drilling techniques are needed Several ways have been found for re-entering the hole and re-circulating drilling muds, these require that a riser pipe, conductor or casing reach to the surface It is even possible to abandon a hole temporarily and recover it again

In depths of 35–360 ft, holes have been drilled to nearly 12,000 ft *CUSS I*, for example, now drilling for oil off the California coast, is a well-designed vessel that would make an excellent deep-drilling experimental platform if it were equipped with a heavier draw-works or hoist (such as are available on the open market) and a deep mooring system

Holding a ship in position in water two and a half miles deep might be accomplished by (1) anchors which are explosion-jetted into the bottom and connected to the ship by neutrally buoyant hawse lines of synthetic material, (2) a dynamic anchoring system in which a group of outboard propulsion units (which can exert propulsive force in any direction) are centrally controlled by an operator who holds his position by watching taut-line buoys and/or listening to a vertical beam of underwater sound rising from a transducer fixed to the bottom

Thus, the mooring, drilling, setting of casing and riser pipe, coring and instrumentation all appear to be well within the bounds of our technology Engineering work has started and funds are being solicited

As the feasibility study progresses, the original cost estimates have shrunk and it now appears that the entire project might be carried out for about 15 million dollars This is not an inconsiderable sum, but it is much less than that of a rocket-propelled moon-probe, the ostensible objective of which is to learn about the nature and origin of the solar system It seems a little foolish to go off to look at the Moon when we do not know what lies a few kilometres beneath us on our own planet

The first phase of the drilling can be accomplished for about 2 5 million dollars, the second for about 9 5 million dollars It is hoped that the project will be financed jointly by private interests and by the U S National Science Foundation Certain related aspects of oceanography and of doing heavy work at sea might be supported by the U S Navy, although no direct military application is foreseen

When drilling will start is uncertain, it will depend on the length of time needed to complete preliminary work and to obtain funds Work could begin on the test holes before the end of 1959 The scientific planning of objectives, locations and instruments, the collection of necessary data and the re-survey of the most promising areas are already under way

AMSOC believes that this series of holes which will eventually sample the mantle of the Earth is likely to produce the greatest advances in man's knowledge of the Earth in our time.

SELECTED REFERENCES

Bascom, Willard, "The Mohole", *Scientific American*, 200, No 4 (April 1959).

Estabrook, Frank, "Geophysical Research Shaft", *Science*, 124 (October 12, 1956).

Gaskell, T F, "A Borehole to the Earth's Mantle ?", *Nature*, 182 (September 13, 1958).

Hess, H H, "The Oceanic Crust", *J Mar Res*, 14, No 4 (December 31, 1955).

Hess, H H, "The AMSOC Deep Hole to the Mantle", address to the American Geophysical Union, May 6, 1959 (Washington, D C).

Jeffreys, Sir Harold, "Earthquakes and Mountains", 2nd edit revised (Methuen, London, 1950).

Lill, G G, and Maxwell, A E, "On Determining the Nature of the Earth's Mantle", *Science*, 129 (May 22, 1959).

Lovering, J F, "On the Nature of the Mohorovičić Discontinuity", *Trans Amer Geophys Union*, 39, No 5 (October 1958).

Wilson, J Tuzo, "Geophysics and Continental Growth", *Amer Scientist*, 47 (March 1959).

ASYMMETRICAL DELIVERY IN RABBITS

By DR. LUIZ MACEDO COSTA* and DR ARPAD CSAPO

The Rockefeller Institute, New York, 21

THE experiments of Corner and Allen[1] and Allen and Reynolds[2], performed on rabbits, promised an understanding of the mechanism by which pregnancy is maintained and terminated in mammals. They also provided us with a key substance which controls these processes, the ovarian steroid progesterone.

The thirty years which followed these discoveries, however, brought disappointments. The different consequences in different species of ovariectomy or oxytocin infusion upon pregnancy, the lack of correlation between uterine activity and the concentration of progestational compounds in body fluids, and the lack of success in predicting effective progesterone therapy in women led many investigators to believe that either progestational compounds do not have a key role in the control of the pregnant uterus, or else a variety of mechanisms operate in different species.

These conclusions are challenged by a striking experiment of Nature which strongly implies that the maintenance of pregnancy is more a local than a systemic affair, thus allowing an explanation of the differences cited above. When a woman who has a duplex or bicornate uterus bears twins, one in each horn, the infants may be born several weeks apart, showing that in the same woman at the same instant conditions can be appropriate for the maintenance, as well as for the termination, of pregnancy[3].

Classical endocrinology limits our thinking to a systemic hormonal control of the uterus by which the glandular product is distributed uniformly in the target organs. This simple experiment of Nature, however, suggests to us that such a systemic control may not operate in all instances. A 'local' effect may be considered instead, when the organ of secretion and its target are in direct contact, allowing diffusion of an active compound from one cell to the next. Thus the local effect of placental progesterone has been postulated and described[4] as an alternate mechanism.

The existence of such a local mechanism could explain present controversial issues concerning the mechanism of the maintenance of pregnancy. Species differences could be looked upon not as differences in basic principles, but, for example, as differences in timing and in magnitude of the shift from ovarian (systemic) to placental (local) progesterone effect, or

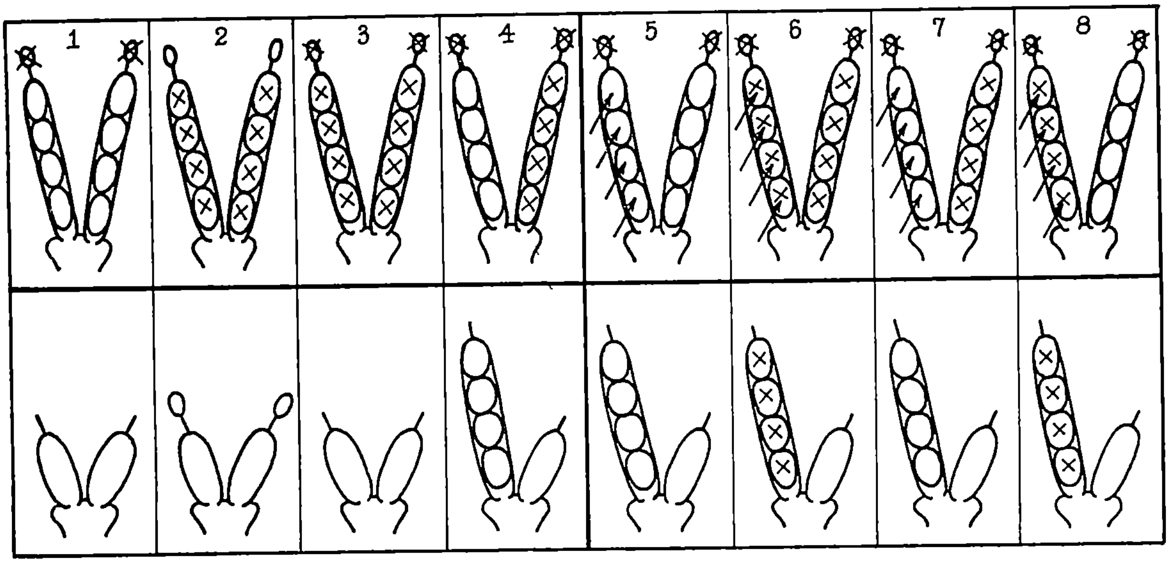

Fig 1. Schematic illustration of the type of operations used in the present study (upper row). Crosses over the ovaries represent ovariectomy, crosses over the conceptuses, placental dislocation. Arrows indicate intraamniotic injection of 2 mgm progesterone in 0.04 ml oil. The lower row represents the effect on delivery of the operation or treatment.

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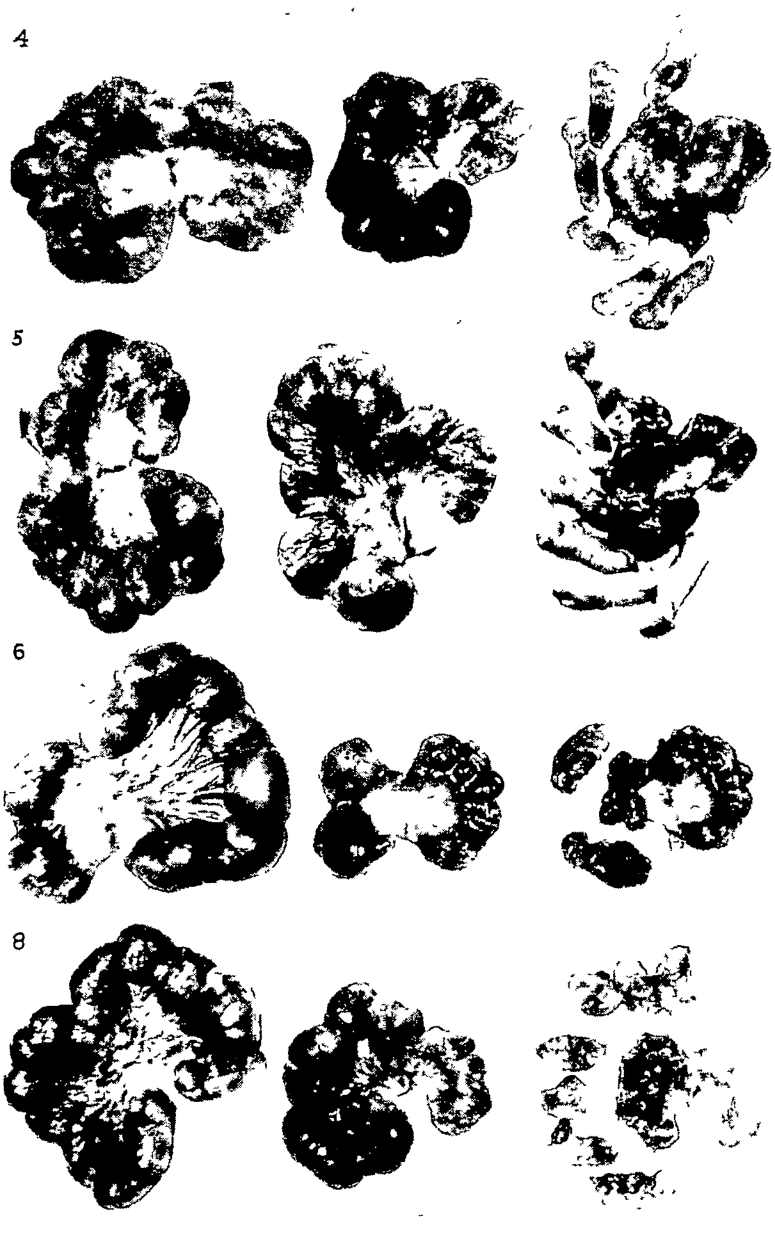

Fig. 2. Asymmetrical delivery in rabbits, induced on the twenty-fifth day of pregnancy. The numbers on the left represent the type of operation as illustrated schematically in Fig. 1. The first picture on the left is taken immediately after the operation, the second is made on repeated laparotomy after delivery is completed in one horn, and the third after the undelivered horn is opened and the fœtuses and placentas examined

as differences in the metabolism and elimination of progesterone, dependent on the exposure of progestational compounds to the systemic circulation, prior to their uptake by target organs. The concentration of progestational compounds and their changes in concentration in body fluids would not be expected to reflect quantitatively the endocrine condition of the uterus because much higher concentrations than occur in the blood or in the urine could be present in key positions at the myometrial cell; in fact, body fluids may contain only the 'leakage' of a local arrangement or what is left from destructive and eliminating processes. The lack of conclusive evidence for the effective use of progesterone in therapy would become a challenge rather than disappointment, because an effective local supply of placental progesterone could be therapeutically initiated only by a similar local application, or by forms of progesterone not subject to systemic destruction.

To demonstrate a local effect of placental progesterone on the myometrium, we studied thirty-five pregnant rabbits in the present experiments. It is generally believed that pregnancy in rabbits is entirely maintained by ovarian progesterone, not supported by placental contribution. We suspected, however, that even in rabbits there may be progesterone production, or effective metabolism, in the placenta in late pregnancy[4a,b,d]. In women, on the other hand, during the last six months of pregnancy the placenta seems to substitute completely for the endocrine function of the ovaries[5].

In our colony of New Zealand white rabbits labour can be induced with 1 i.u. 'Pitocin' (Parke-Davis), intramuscularly, in 94 per cent of the animals 31 days after mating. Only 7 per cent of the animals deliver after similar treatment (even if repeatedly applied), if the animal is less than 30 days pregnant.

We ovariectomized rabbits bilaterally (op. No. 1) on the twenty-fifth day of gestation (duration of pregnancy = 32 days) and found that 13 hr. after the operation 1 i.u. of 'Pitocin' successfully induced delivery.

If the ovaries were not removed (op. No. 2), but all the placentas in both uterine horns were dislocated (by gently pressing the uterine horn at the placental implantation site), placental function ceased and delivery was successfully induced by 'Pitocin' 20 hr. later. This is evidence that the rabbit placenta is indispensable for the maintenance of pregnancy.

If the two procedures, ovariectomy and placental dislocation, are combined (op. No. 3), labour can be induced 9 hr. later. These observations suggest that in the rabbit both the ovaries and the placentas contribute to the maintenance of pregnancy. When both these possible sources of progestational compounds are removed, the myometrium has enough stored material to defend pregnancy for 9 hr. against the labour-inducing effect of 1 i.u. 'Pitocin'. The placentas can prolong this period for four additional hours and the ovaries for 11 hr. This suggests that the ovarian contribution is three times as great as the placental.

If after any of these operations 'Pitocin' is not administered, spontaneous delivery ultimately occurs; but the time between operation and delivery, as well as the time needed for delivery, is greatly prolonged. Also, the mother may destroy or partly eat the uterine contents, which makes accurate timing and observations difficult For this reason we induced labour with 'Pitocin'

It may be argued that the rabbit placenta only stores, but does not produce, an active progestational compound The following experiment, however, suggests that the placental contribution is not only storage, but also synthesis or effective metabolism If ovariectomy is combined with the dislocation of one set of placentas, in one horn only (op No 4), this horn alone delivers 9 hr later on 'Pitocin' administration, whereas pregnancy is maintained in the other horn This asymmetrical delivery, resulting from the presence of a set of functional and another set of non-functional placentas in two horns, respectively, is indication of the production of an active compound as well as evidence of the local effect of the placenta

It might be said, however, that the active compound of the placenta is not like progesterone, but is an entirely different compound This is unlikely, since the local effect of the dislocated placentas can be substituted for by the injection of 1–2 mgm progesterone into the amniotic sac If only one horn is treated with progesterone in the ovariectomized animal, delivery is always asymmetrical The untreated horn delivers first, irrespective of whether the placentas in one horn are dislocated or not (op Nos 5–8) The time when delivery occurs reflects a functional or non-functional set of placentas, but the phenomenon is the same, that is, delivery is asymmetrical if the distribution of progesterone is asymmetrical Whether the litter is alive or not does not alter the picture, nor does the mechanical irritation of the uterine horn during the operation

These observations are best explained as follows Pregnancy in rabbits is maintained by a joint contribution of an active progestational compound by the ovaries (systemic) and placentas (local) The placental contribution is less than that of the ovaries, but both organs are needed to maintain an effective concentration of the active compound in the myometrial cell When the defence is effective, labour cannot be induced by 'Pitocin', if it becomes ineffective, labour can be induced When the systemic effect of the ovaries is suspended by ovariectomy the local effect of the placenta controls the uterus and if this local effect is asymmetrical, labour is asymmetrical

In women, an early and complete shift from ovarian to placental hormone production could result in a dominant local progesterone effect early in pregnancy This would lead to an 'endocrine asymmetry', resulting in asymmetrical function Such an asymmetry is exaggerated in a bicornate uterus when endocrine function in one placenta fails earlier than in the other Functional asymmetry of the human uterus offers attractive explanations of puzzling problems concerning normal and abnormal pregnancy and delivery

[1] Corner, G W, and Allen, W M, *Amer J Physiol*, 88, 326 (1929)

[2] Allen, E M, and Reynolds, S R M, *Amer J Obst Gynec*, 30, 309 (1935)

[3] Kennedy, N, *Brit Med J*, 5121, 486 (1959)

[4] (*a*) Csapo, A, in "Recent Progress in Hormone Research", 12, 403 (Academic Press, New York, 1956), (*b*) *Amer J Anat*, 98, 273 (1956), (*c*) *Ann N Y Acad Sci*, 75, 790 (1959) (*d*) Goto, M, and Csapo, A, *Biol Bull*, 115, 335 (1958)

[5] Ask-Upmark, M E, *Acta Obst Gynec Scandinav*, 5, 211 (1926)

WARREN SPRING LABORATORY, STEVENAGE

IN setting up Warren Spring Laboratory at Stevenage "to carry out process research and development over a wide field not limited to particular areas of technology", the Research Council for the Department of Scientific and Industrial Research expressed its conviction that, when necessary, the Department's research stations should change in function and objective to meet the needs of changing situations The Council considered that the Fuel Research Station had largely fulfilled the aims in view when it was set up, and that current needs were satisfactorily catered for by researches going on elsewhere, it decided, therefore, to close down the Fuel Research Station, and to transfer the staff to a new Laboratory in Stevenage, with new programmes To ensure that there should be no likelihood of an impression being gained that the Fuel Research Station was being continued at Stevenage, or that the title of the new Laboratory might appear to restrict the field of activity, it is named after a lane which used to run across the site

Of the work carried out at the Fuel Research Station only two programmes have been transferred to the new Station, namely, research on the abatement of atmospheric pollution, and on the synthesis of oils and chemicals by the Fischer–Tropsch process

There had been a number of substantial indications of need for research in the field of mineral processing, and it was decided that this should form one of the new projects to be undertaken, there had also been indications of need for work on a pilot scale in various fields which the Department had not been able to meet With these pointers, it was decided to build a laboratory in a modern industrial style, to be as flexible as possible, to house in the first place a staff about the size of that of the Fuel Research Station, and with facilities for both laboratory research and pilot-scale work

The main three-story laboratory building is 372 ft long and 37 ft 6 in wide (Fig 1) It is based on a 4-ft module, which is expressed elevationally by vertical posts supporting floors and roof, and by internal posts centrally along the length The main spine corridor is set to one side of the central supports The only solid internal walls are those of the corridor and the secondary staircases, all other partitioning is of light, demountable, prefabricated construction, which can be placed in any desired position between the outer walls and the inner corridor walls, subject only to the basic 4-ft module

Gas, water, electricity, compressed air are available at every third module (12 ft) along a perimeter distribution system

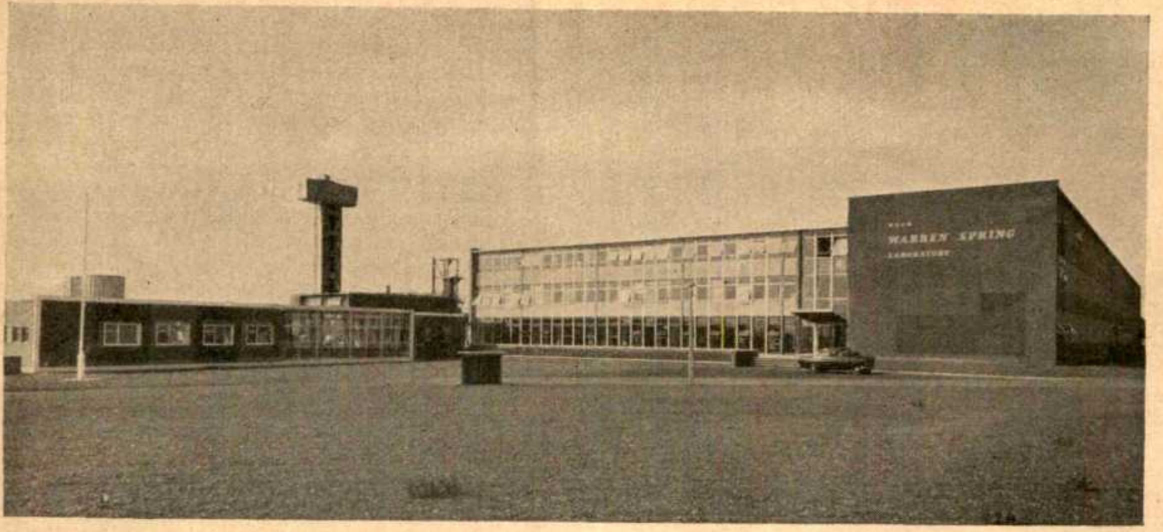

Fig. 1. The Warren Spring Laboratory, Department of Scientific and Industrial Research

The building is heated by panel-type radiators; made-up dummy panels matching them are inserted between the radiators to give the appearance of a continuous radiator panel along each wall between the concrete columns at 12-ft. centres. The radiators and the dummy panels conceal the services which run around the perimeter of the building. The dummy panels can be readily removed when service connexions are required. Fume cupboards are ranged along the inner, corridor walls, each cupboard having its own extract duct which discharges at roof-level.

The finishes are simple, self-coloured, fair-faced brickwork being used throughout, except in laboratories with special functions. With the exception of laboratories which are adapted for wet processes, floor finishes are in linoleum.

A three-story administration block runs at right angles to the main laboratory building; it is similar in construction and design except that there is a lower ceiling height.

There are three pilot-scale buildings, each 90 ft. long by 55 ft. wide by 37 ft. 6 in. maximum height. In two of them, a 20-ft. wide section is 20 ft. high only. These buildings are linked to the main laboratory block by a corridor with small-scale laboratory units on each side. The buildings have folding doors to the side bays to permit the introduction of heavy plant at any point. The structure is carried by precast concrete posts. Vertical cladding, above a brick protective walling, consists of asbestos–cement sheeting and patent glazing; the roofs are of asbestos–cement decking overlaid with bituminous felt.

The workshops and engineering stores occupy a large steel-framed building comprising six east-light bays, each 60 ft. by 30 ft. minimum headroom.

Since steam is required night and day for process purposes, two fully automatic, oil-fired, high-efficiency boilers are used, with a nominal pressure of 120 lb./sq. in.; one is rated at 10,000 lb. and one at 5,000 lb. of steam per hour. The front of the boiler house is fully glazed with a patent system permitting ready removal in sections when boiler tube replacements are necessary, so that it is possible to reduce the dimensions from front to rear. A high-level water reservoir, in reinforced concrete, has been designed integrally with the boiler flue (see Fig. 1).

Service mains run in open, splay-sided trenches to avoid the expense of underground ducts or the unsightliness of overhead gantries.

The total cost of the establishment, including buildings, services fixed, laboratory fittings, library bookshelves, and all site works was approximately £620,000.

Research Programmes

Atmospheric pollution. Purely by coincidence the closing of the Fuel Research Station occurred simultaneously with the introduction of the Clean Air Act; it was therefore particularly apposite to review the programme in starting at the new station. The work now being undertaken follows naturally from that begun at the Fuel Research Station, and is designed to meet the requirements of the Ministry of Housing and Local Government.

The principles of smoke-elimination that have proved successful in reducing smoke from hand-fired boilers on land are being applied to marine boilers. The possibility of developing after-burners to burn smoke in various situations is being investigated.

The properties of smokes from different sources are being examined with special reference to the constituents that might be injurious to health. The occurrence of oxides of nitrogen in the atmosphere under different conditions is being studied.

In the new investigations of air pollution there is a need for greater accuracy than has been possible in some of the measurements made in the past. As a matter of urgency a review is being made of the principal instruments at present in use; this work is being undertaken by the Scottish Branch of the Laboratory at Thorntonhall.

Micro-surveys are in progress to examine the concentration of various types of pollution at different types of site in a limited area. The results of such investigations will be important, for example, in helping to determine the value of smoke-control areas, and in assisting those responsible for deciding the height of siting of large industrial chimneys.

Process development. Synthesis of oils and chemicals from carbon monoxide and hydrogen is being studied as part of a project to develop, if possible, an economic process for producing oil from coal. The development of oils from coal is a two-stage process: the first stage involves the complete gasification of the coal to yield a mixture of carbon monoxide and hydrogen, and the second the catalytic conversion of the gas mixture into the desired end-products. The work at Warren Spring Laboratory is concerned only with the second of these stages. Economic considerations indicate that the most promising version of the Fischer–Tropsch process for use under British conditions is the slurry process, in which the gas mixture is passed through a suspension of powdered catalyst in molten wax at temperatures of 250–300° C., and at pressures between 5 and 30 atmospheres.

The objectives of the programme are: (1) to develop an iron catalyst of longer life and higher activity than those at present available and one that will yield a high proportion of desired end-products; (2) to select operating conditions (gas composition, temperature, pressure) to combine a high reaction velocity with a given distribution of end-products; (3) to obtain data necessary to design a full-scale reaction vessel.

Synthesis gas is produced on the site at a rate of 4,500 std. cu. ft. per hr. in a standard, water-gas generator operated by the Engineering Services Division. There are arrangements for feeding carbon dioxide with the steam so as to vary the hydrogen: carbon monoxide ratio between 1·15 and 0·6. The gas is purified from hydrogen sulphide in Gastechnik towers and washed with caustic soda to control the carbon dioxide content. It is then compressed to 15 atmospheres pressure in the first two stages of a four-stage compressor, passed through the active carbon scrubbers to remove organic sulphur compounds, and then further compressed in the third and fourth stages to a pressure of 120 atmospheres.

The study of catalysis, which has been proceeding over a number of years at the Fuel Research Station, has brought to the team concerned considerable experience which should prove of value in some of the new programmes which it is hoped to undertake in the future.

Mineral processing research and development. Dr. M. G. Fleming, of the Bessemer Laboratory of the Royal School of Mines, has been appointed consultant to this Division.

It seems probable that for some time a fair proportion of the effort of this Division will be engaged on sponsored work on particular ores; but it is hoped that basic investigations will include: (1) a study of grinding in the presence of additives such as surface-active agents; (2) the kinetics of bubble attachments to mineral surfaces, as a contribution to the knowledge in the field of froth flotation; and (3) a study of the behaviour of mineral particles in a high-tension field, and the modification of this behaviour by various surface treatments.

The laboratories are equipped to handle most laboratory-scale mineral-dressing operations such as flotation, jigging, tabling, heavy-media separation, wet and dry magnetic separation, and high-voltage separation. In the hydrometallurgical field, facilities are available for atmospheric and pressure leaching, for fluidized-bed roasting, chlorine metallurgy, and solvent extraction. Pilot-plant facilities enable primary crushing operations to be carried out on a scale up to 2½ tons per hour, and flotation plant is available for treating up to 1,000 lb. per hr. It is possible to carry out full-scale tests with radioactive tracers. The Division has a Mineralogical Section, but relies on the Physical and Chemical Services Division for its analytical work.

Many of the problems on which work is likely to be necessary concern overseas deposits. Already a number of requests for investigations have been received from overseas territories, and an Overseas Mineral Processing Advisory Committee has been set up to advise on the selection and priorities of the programmes of interest to these territories.

Chemical engineering. It will be apparent that chemical engineering must play a large part in practically all the major activities of the Laboratory, and the decision of the Research Council to transfer "the work on Chemical Engineering . . . carried out at the National Chemical Laboratory to Warren Spring Laboratory" will readily be understood.

The Division has three functions: (1) to carry out research on physical operations which play an important part both in processes which are under development in the Laboratory, and those in more general use in industry; (2) to undertake research in the field of chemical engineering sponsored by industry or by Government departments; (3) as a result of these functions to accumulate basic information in chemical engineering for use by other sections of the Laboratory and industry.

Bearing in mind work that is already going on elsewhere in the Department on heat transfer and on fluid flow, it is proposed in the first instance to concentrate on the field of mass-transfer, and in particular to obtain results which will permit more accurate prediction of the performance of gas–liquid contacting equipment, and thus to facilitate the design of distillation columns, gas-absorption towers, and reactors of the liquid-phase type, of which the Fischer–Tropsch slurry reactor is a particular example.

Four main lines of study are being followed, namely, bubble dynamics, gas-liquid mass transfer rates, fluid mixing, and specific problems in gas absorption with chemical reaction.

The National Engineering Laboratory of the Department has sponsored work at Queen Mary College, London, on the synthesis of organic compounds for use as drop-wise condensation promoters and has evaluated their effectiveness. The proposed work at the Warren Spring Laboratory is being planned in consultation with the National Engineering Laboratory and is intended as a study of the mode of action of these promoters in order to facilitate the development of compounds which will be effective for prolonged periods with a wide range of metal surfaces. It is proposed to study the mechanism of attachment of synthetic promoters to metal surfaces by methods of radiochemical labelling and to observe the subsequent history of these substances under conditions of use in heat exchangers.

Physical and Chemical Services Division. This provides a comprehensive central service in the fields of analysis, both by chemical and physical methods, instrument development, physical measurement, and photography. Special equipment includes gas chromatography, quartz and infra-red spectrometers, and equipment for X-ray diffraction and fluorescence spectrometry.

Engineering Services. This Division has a drawing office which undertakes design of pilot-scale plant for the Laboratory; it has an industrial staff of approximately 120, and well-equipped workshops.

Intelligence. In addition to the library and editorial services which are essential to any research establishment, the Intelligence Division is setting out to provide an information and project appraisal service A start has been made, for example, in building up a centre of information in mineral processing, by assembling data from a wide variety of sources in such a way that they can be used in research and industry

From what has been described it will be apparent that there is a wide choice of field before Warren Spring Laboratory, and that at the moment the main problem is that of selection, and of allocation of priorities In addition to the factors which govern the work of other laboratories of the Department of Scientific and Industrial Research, there is the task of undertaking sponsored work to a greater extent, and on a larger scale Such work may be carried out for Government departments or for industry, and it may be on a fully confidential basis The special facilities of the Laboratory will also be available for use, in certain circumstances, by teams from industry, which can work in collaboration with the research staff of the Laboratory

The programme is regularly considered by a Steering Committee, appointed by the Research Council, the present members of which are Sir Harry Jephcott (chairman), Sir Harry Melville, Dr R Holroyd, Mr D A Oliver and Mr S H Clarke.

OBITUARIES

Mr T. L. Eckersley, F.R.S.

THE death of T L Eckersley on February 15 removed another of the rapidly dwindling band of pioneers in the field of radio research, among whom he was notable both for his theoretical and practical work His interest in electromagnetic waves was aroused while he was still at school at Bedales, but it was during the First World War, after studying at University College, London, and Trinity College, Cambridge, with some years at the National Physical Laboratory in between, that he made his first big contributions to radio-wave propagation These were his explanation of 'night-effect' in direction-finding observed in Egypt and Salonika, in which he invoked the existence of an upper ionized layer giving rise to a reflected wave with variable polarization characteristics, and his observation of coastal refraction which he sought to account for in terms of the properties of Zenneck surface waves

He was thus among the first to obtain evidence of the presence of the ionosphere by the reflexion of radio waves and so began a life-long interest in the magneto-ionic theory of propagation His first work, however, on joining the Marconi Co after the War was a classical research into the properties of earth screens for increasing the radiation efficiency of long-wave aerials, followed by his analysis of the results of observations made on very long-wave transmitters by K W Tremellen and C M Allnutt during a round-the-world expedition For more than twenty years Tremellen was Eckersley's personal assistant, and his patient observational work formed the basis of the succession of papers which Eckersley wrote on short-wave radio transmission

The last of these was on scattering from 'clouds' in the ionosphere, a subject which has since become of great practical importance in the development of the ionospheric 'forward scatter' communication system Not only did all this work lay the foundation of much of our knowledge of the part played by the ionosphere in long-distance propagation, but it also led to many advances in technique, for example, in the field of accurate direction-finding and in the measurement of field-strength and polarization characteristics

Although he would not have claimed to be a pure mathematician, he had a consummate ability to apply mathematics to physical problems Indeed, many of his experimental researches were preceded or supported by elegant analysis He had a great interest in modern physics, especially in its quantum and relativistic aspects, and it was the knowledge so acquired that inspired some of his finest work in radio It was the phase integral treatment of potential barriers in atomic theory that led him to his brilliant applications to ionospheric and ground-wave propagation, while in the scattering of α-particles he found an analogy for the scattering of radio waves as a function of wave-length, cloud size and scattering angle

Eckersley had something of the absent-mindedness associated with genius, which was reflected in the style of his writing and made some of his papers difficult for others to read He was thus not as well known in the world at large as he deserved to be, but in due course full recognition among scientists came with his election to fellowship of the Royal Society in 1938 and the award of the Faraday Medal of the Institution of Electrical Engineers in 1951 He was also a well-known figure at international radio conferences, especially at the C C I R and U R S I assemblies

He was proud of the fact that he was a grandson of T H Huxley, and he was most happy in his family life, his wife being Eva, the daughter of Barry Pain, the Victorian novelist, who survives him with a son and two daughters She is an able pianist and composer, and their home at Danbury, Essex, was often visited by distinguished musical friends He was a delightful host, for he combined great courtesy with a delicate sense of humour, and though he did not play himself he had a great love of music

At the time he died he had become almost completely helpless from multiple sclerosis, the first symptoms of which had appeared more than twenty years ago In spite of increasing disability, he remained at work throughout the Second World War as scientific adviser to the Inter-Services Ionosphere Bureau at the Marconi Research Laboratories, and after his retirement in 1946 he continued to work at home for several more years

During this period he published a number of papers, his devoted wife acting as his amanuensis There is no doubt that it was her amazing courage and cheerfulness that maintained his life for so long, and indeed it was to pneumonia during the influenza epidemic that he finally succumbed The loving care which surrounded him during those last years was a source of inspiration to all who witnessed it

G MILLINGTON

Prof A O R Windaus

ON June 9 it was reported from Gottingen that Adolf Windaus had died in his eighty-third year He had retired as professor and director of the University Chemical Laboratory at Gottingen in 1938, and was made emeritus professor and director in 1944

Windaus was born in Berlin in 1876, educated at the Universities of Berlin and Freiburg-im-Bresgau and became *Privatdozent* in 1903 After a short period at Innsbruck, he was elected to Gottingen in 1915 He was awarded the Nobel Prize for Chemistry in 1928, and also received the Baeyer, Pasteur and Goethe Medals

To those interested in steroids, Windaus's name will stand with that of the late Heinrich Wieland as the greatest in the period of German pre-eminence in discovery about the chemistry and physiology of these substances Most of his publications between 1903 and 1928 were about cholesterol and described, *inter alia*, the preparation of complexes with digitonin, solanin, etc (1909, 1918), the nature of the side-chain (1913) and the relationship to coprosterol (1916) and to the bile acids (1919) Papers also appeared on stigmasterol (1906, 1924), sitosterol (1918, 1924), hydrodeoxycholic acid (1923, 1926), chenodeoxycholic acid (1924, 1925, 1926) and on 'β'-phocæcholic acid (1928) All this work and much more, including some on heart poisons and saponins, was done without modern knowledge of steroid formulæ, yet Windaus's fundamental discoveries stand largely unchallenged to-day His work on scymnol (with W Bergmann and G Konig, *Hoppe Seyl Z*, **189**, 148, 1930) was the first on the chemistry of this substance The paper with Alfred Hess, of Columbia University, New York, entitled "Sterine und antirachitisches Vitamin" and published at the session of the Gesellschaft der Wissenschaften zu Gottingen on January 28, 1927, clearly recognized that both ergosterol and an impurity separable from cholesterol acquired antirachitic activity on irradiation with ultra-violet light Parallel work had already begun in England (for example, I M Heilbron, E D Kamm and R A Morton, O Rosenheim and T A Webster, *Chem and Indust*, **45**, 932, 1926), it was energetically pursued there, and also by Windaus and his colleagues until, in 1931, success in isolating a pure vitamin D was announced almost simultaneously from Gottingen and Hampstead, London From irradiated ergosterol, F A Askew, H M Bruce, R K Callow, J St L Philpot and T A Webster (*Nature*, **128**, 758, 1931) obtained calciferol, and Windaus and O Linsert (*Liebigs Ann*, **489**, 269, 1931) vitamin D_2 · these substances were later found to be identical, although the separate names were retained

'Vitamin D_1', originally reported as pure by the German workers (*Liebigs Ann*, **489**, 252, 1931), was later proved (*ibid*, **493**, 259, 1932) to be a molecular compound of vitamin D_2 and lumisterol

For Windaus, this was by no means the end of the vitamin D problem Doubts as to the identity of calciferol (vitamin D_2) and the antirachitic vitamin of fish-liver oils persisted, and C E Bills (*Physiol Rev*, **15**, 1, 1935) summarized evidence that the antirachitic vitamin in irradiated (impure) cholesterol and in cod liver oil (as measured in 'rat units') is more potent for chicks than the vitamin (calciferol) in irradiated ergosterlly

Windaus brilliantly recalled that J Mauthner and W Suida in 1896 (*Mh Chem*, **17**, 579) had oxidized cholesterol with chromic acid to 7-ketocholesterol, and, with H Lettré and Fr Schenck (*Liebigs Ann*, **520**, 98, 1935), he reported the conversion of this substance into 7-dehydrocholesterol Irradiation of this gave a mixture from which was isolated (Windaus, Fr Schenck and F von Werder *Hoppe Seyl Z*, **241**, 100, 1936) vitamin D_3, identical with the natural vitamin obtained from tunny liver oil by H Brockmann (*Hoppe Seyl Z*, **241**, 104, 1936) at Gottingen Windaus's later papers were about the chemical nature of natural forms of vitamin D and the chemistry of irradiation products of ergosterol and 7-dehydrocholesterol

Windaus's publications, which ceased in 1944, remain as an inspiring example of what a great intellect can still accomplish in scientific discovery

G A D HASLEWOOD

Dr F Busemann

DR FELIX BUSEMANN, who died on April 30 at the untimely age of fifty-one, was an outstanding authority in his chosen subject, electrical transmission, as is his brother, Adolf Busemann, one of the leading German aerodynamicists now in America Trained at the Institute of Technology, Darmstadt, he became later assistant to the professor of electrical machine design there, and in 1934 joined the firm of Siemens Schuckert in Berlin, becoming one of a team concerned with future developments in electrical transmission This team had as one of its assignments that of high-voltage direct-current transmission Starting with a pilot scheme between Charlottenburg and Moabit, it followed by planning the Siemens Schuckert half of the major Elbe–Berlin project After the Second World War, Dr Busemann was chosen by the Darwin Panel and came to Britain in 1946 to report on the German work in this field

Busemann found the social climate in Britain so akin to his temperament that he shortly accepted an offer to join the staff of the Electrical Research Association and continue his studies on d c transmission These resulted in a masterly series of fourteen reports covering all aspects of the subject with the exception of valves, for the study of which facilities were lacking He played a major part in the planning of a pilot scheme which, had it matured, would have placed Great Britain in the van of development He was without doubt the foremost authority on high-voltage direct-current transmission in Britain, and his loss will be greatly felt

With the temporary cessation of interest in direct-current transmission, Busemann turned his versatile mind to other aspects of transmission Among these he devised, jointly with W Casson, a classic programme of full-scale experiments on power-system stability (Cliff Quay), described in a paper before the Institution of Electrical Engineers last year More recently, he had been concerned with mechanical and thermal properties of soil and utilization of power cables To all these he brought quick appreciation of decisive factors and great facility in analysis and exposition

Behind a natural modesty Busemann had great personal charm and humour as well as perception He was a musician of almost professional attainment and gave much service to his church and the social activities of the Electrical Research Association He will be remembered by all who knew him for a long time to come He leaves a widow and two daughters

L GOSLAND

Miss Grace M. Sickles

Grace M. Sickles, associate research scientist in the Division of Laboratories and Research of the New York State Department of Health, died on June 29 at Troy, New York. An eminent bacteriologist and virologist, Miss Sickles had been a member of the Health Department since 1918, with a two-year period of service (1919–20) in the Communicable Disease Laboratories of the United States Army. She was a graduate of the New York State College for Teachers and a member of the principal scientific societies in her fields of research.

Miss Sickles was associated with Dr. Augustus B. Wadsworth in an extensive series of investigations on the production and standardization of antipneumococcus, antimeningococcus and antistreptococcus sera, studying, as early as 1938, the action of immune serum in conjunction with chemotherapy in experimental streptococcus infections. Some of Miss Sickles's studies of diphtheria toxin and on the antibiotic activity of micro-organisms from the soil were carried out at the Marine Biological Laboratory, Woods Hole, Massachusetts.

Miss Sickles was the discoverer with Dr. Gilbert Dalldorf in 1947 of the coxsackie virus. The virus was identified during a study of outbreaks of poliomyelitis in New York State. It was named after the village in which the first two recognized human infections occurred. The coxsackie group now includes more than a dozen viruses which are common sources of infection in man.

Mr. W. E. Perry

The sudden death on June 5 of Mr. W. E. Perry, a senior principal scientific officer at the National Physical Laboratory, Teddington, removes one of the leading figures in the field of radioactive and radiation standardization. Born in 1903, Perry took his degree from Nottingham and joined the Laboratory in 1928. He was responsible for re-measurement of the National Radium Standards in 1934, and for the subsequent development of radioisotope measurements. Later, as head of the Radiology Section at the Laboratory, he had charge of the work on radioisotopes, X-ray dosimetry, neutron standardization and radiocarbon dating, and had an international reputation for his scientific integrity and wide knowledge in these subjects. At the time of his death, he was preparing material for the ninth International Congress on Radiology at Munich, in his capacity as chairman of Committee I of the International Commission on Radiological Units and Measurements.

NEWS and VIEWS

The British Association: New President

Sir George Thomson, master of Corpus Christi College, Cambridge, has been elected president for 1960 of the British Association for the Advancement of Science, in succession to Sir James Gray. Sir George has had a distinguished career as a physicist, as a man who gave outstanding service to the Atomic Energy Project in its early days and as master of Corpus Christi College. The son of the late Sir J. J. Thomson, he was educated at Trinity College, Cambridge, obtaining a first-class degree both in the Mathematical and in the Natural Sciences Tripos. After service in France with the Army, followed by research on aeronautical problems, he was appointed to the chair of physics at Aberdeen in 1922, where he carried out the epoch-making work on the defraction of electron beams by thin metal foils, thereby establishing beyond doubt the wave nature of the electron. For this work he was awarded the Nobel Prize for Physics in 1937. Between 1930 and 1952 he was professor of physics in the Imperial College of Science and Technology, London, and was chairman of the first British Committee on Atomic Energy, the Maud Committee, appointed in 1940. He has played a considerable part in the development of the subject ever since, being interested not less in its social as well as in its scientific aspects. Since his appointment to the mastership of Corpus Christi College, his interest in physics has continued and he has published work on gas discharges and has been chairman of Section *A* (Mathematics and Physics) of the British Association. Both on account of the great distinction of his scientific work and his interest in the wider implications of scientific advance he will be a most welcome president of the British Association.

Director of the Royal Aircraft Establishment: Prof. M. J. Lighthill, F.R.S.

Prof. M. J. Lighthill, Beyer professor of applied mathematics at the University of Manchester since 1950, has been appointed director of the Royal Aircraft Establishment, Farnborough, in succession to Sir George Gardner, who is succeeding Air Chief Marshal Sir Claude Pelly as controller of aircraft at the Ministry of Supply in October.

Prof. Lighthill has made outstanding contributions in many fields of fluid dynamics as well as in more general spheres of pure and applied mathematics. His applications of the fundamentals of mathematics to various aeronautical problems have been significant and widespread. He is particularly well known for his theoretical work on jet noise; this work, which has been largely substantiated by experiment, relates the noise to the turbulence in the jet. He has always displayed a continuing interest in the practical application of his theories, and has been for a number of years a member of the Aeronautical Research Council. Prof. Lighthill was educated at Winchester and Cambridge, and was elected to the fellowship of the Royal Society in 1953 at the early age of twenty-nine.

Royal College of Science and Technology, Glasgow: Sir David Anderson

Sir David Anderson, who is to retire from the post of director of the Royal College of Science and Technology in December 1959, was appointed principal of Derby Technical College in 1926 at the age of 31. In 1930, he became principal of the Central Technical College, Birmingham, and in a period of 16 years which spanned the arduous war years, he laid the foundations of the College of

Advanced Technology, designated as such by the Minister of Education in 1956. In this period, too, he became increasingly concerned with the problems of technical education at national level. This was especially true of his work as a member of the Percy Committee which reported in 1946, and greatly influenced the development of post-war technical education. He was president of the Association of Principals of Technical Institutions in 1932, and chairman of Council of Association of Technical Institutions in 1951. He was a member of Council of the Institution of Mechanical Engineers during 1941–42, 1948–50. First and foremost a Glasgow man, he was educated at Whitehill School, then at the then Royal Technical College, and served his apprenticeship with the North British Locomotive Company. He returned to the College as director in 1946, and the new engineering block, the recently opened students union, the Residential School of Management Studies at Bearsden, and the new students residences are visible signs of his vigorous leadership. He has continued to serve on a large number of bodies at national level, and was knighted in 1957. After the manner of present times, we may hope that Sir David will not retire from all public work, otherwise the constructive contributions of his incisive mind will be greatly missed.

Dr. S. C. Curran, F.R.S.

The Governors of the Royal College of Science and Technology, Glasgow, have announced the appointment of Dr. S. C. Curran as principal in succession to Sir David Anderson, the retiring director. Dr. Curran studied at the Universities of Glasgow and Cambridge, graduating M.A., B.Sc., Ph.D. (Glas.), and Ph.D. (Cantab.). His early researches were concerned with radiation phenomena and new methods of detection. While at St. John's College, Cambridge, and the Cavendish Laboratory, he pioneered in investigations of proton capture.

During the Second World War he shared in the successful work of the Royal Aircraft Establishment on proximity fuses and of the Telecommunications Research Establishment on the research and development of centimetre radar, having charge of one of the groups responsible for H_2S and ASV; thereafter he joined the British Mission on Atomic Weapons in the United States. At Berkeley he discovered the original form of the scintillation counter and the vacuum carbon arc. Later at the University of Glasgow he introduced the modern form of proportional counter, determining with it the form of novel beta-spectra such as that of tritium. An active research group soon grew up under his leadership.

In early 1955 he joined the Atomic Weapons Research Establishment, where he later became a chief scientist and member of the Management Board responsible for the divisions of Nuclear Research and Electronics. He also served as visiting member on the Harwell Management Board. A considerable growth of nuclear research has taken place at Aldermaston during his years there.

Dr. Curran was awarded the D.Sc. and Kelvin Prize of Glasgow in 1950 and elected to fellowship of the Royal Society in 1953.

Jean Senebier (1742–1809)

Jean Senebier, who died of "une cruelle maladie" at Geneva 150 years ago on July 22, 1809, is an anomalous figure in the history of botany. A clergyman untrained in the scientific method, yet possessing the true scientific spirit, endowed with curiosity, intelligence, and industry, he had many interests: theology, botany, microscopy, physics, chemistry, meteorology, library classification. His tiresome rhetoric prevented his being appreciated by his generation. The son of a protestant tradesman of French origin, he was born on May 6, 1742, at Geneva, where he became pastor in 1765 and chief librarian in 1773. In 1792 political unrest banished him from the city for seven years. Senebier is remembered chiefly for his studies on the influence of light on vegetation. Jan Ingenhousz, an engineer of Dutch extraction, in 1779, introduced the concept of balance of animal and vegetable life by showing that plants generate dephlogisticated air. This activity was demonstrated by Senebier between 1782–88 to be confined to the green parts of plants which, under the influence of sunlight, convert fixed air (carbon dioxide) into dephlogisticated air (oxygen). His "Mémoires physicochimiques sur l'influence de la lumière solaire pour modifier les êtres des trois règnes de la nature" in three volumes were published in 1782. The first to formulate a theory, in strictly chemical terms, of vegetable nutrition in his 'tediously prolix' (Sachs) five-volume "Physiologie végétale" (1800), he stimulated his fellow Genevan, Nicholas Théodore de Saussure, to write his "Recherches chimiques sur la végétation" (1804), which was to eclipse his own work. He was a coresponding member of the Institut de France and of the Royal Academy of Turin.

International Commission on Higher Education in Nigeria

Sir Eric Ashby (vice-chancellor of the Queen's University of Belfast and master-elect of Clare College, Cambridge) returned from Lagos on May 7, after attending the inaugural meeting of the International Commission on Higher Education in Nigeria. The Commission (*Nature*, 183, 1231; 1959), with Sir Eric Ashby as chairman, consists of two other United Kingdom members, Dr. J. Lockwood (master of Birkbeck College) and Dr. G. E. Watts (principal of Brighton Technical College), and three American members, Dr. Frank Keppel (dean of the Graduate School at Harvard University), Dr. Eric Walker (president of Pennsylvania State University) and Prof. H. W. Hannah (associate dean of agriculture, University of Illinois). The Nigerian members are Shettima Kashim (formerly Federal Minister of Social Services, chairman of Nigerian College of Technology), Prof. K. O. Dike (vice-principal and professor of history, University College, Ibadan) and Dr. S. D. Onabamiro (senior research fellow in parasitology, University College, Ibadan).

Sir Eric Ashby, speaking at the inauguration meeting in Lagos on May 4, described the decision to set up a Joint Nigerian–United States–United Kingdom Commission as a "Landmark in educational history" as this was the first time that such an international group had been appointed to study higher education in Nigeria. He assured the meeting that the Commission would be able to recommend some of the educational needs of the first twenty years of Nigerian independence could be met, and that it would do its best to prepare for Nigeria something which could be turned into action.

'Procinyl' Dyes

Imperial Chemical Industries, Ltd., has introduced 'Procinyl' dyes, a new class of disperse dyes. It is claimed that the initial four 'Procinyl' dyes display on nylon and other polyamide fibres the desirable attributes of the established disperse dyes—good levelling, good coverage of irregular-dyeing yarns, good compatibility in admixture, good temperature-range properties and good penetration They are applied in a similar manner The essential difference is that the 'Procinyl' dyes are applied initially under slightly acid instead of neutral conditions, and that dyeing is completed by an alkaline fixation stage during which certain reactive groups in the 'Procinyl' dye molecules react chemically and irreversibly with the amine or amide groups in the polyamide fibre and so produce dyeings of high wet-fastness All forms of nylon and other polyamide fibres, of both the staple fibre and continuous-filament types and including woven piece goods, knitted piece goods and hosiery, can be dyed satisfactorily with the new dyes, which may be applied, as necessary, on the jig (covered jigs for preference), on winches, in paddle dyeing machines and in circulating-liquor machines The initial four 'Procinyl' dyes—a yellow, an orange, a scarlet and a blue—permit an extensive range of shades to be produced because of the wide intercompatibility of the new dyes

Only slight or negligible reaction takes place between 'Procinyl' dyes and acetate and triacetate rayons, for which the new dyes are not expected to be of much immediate interest, although the wet-fastness achieved is generally better than with normal disperse dyes With the exception of 'Procinyl Yellow G', the dyes are of minor importance on 'Terylene' and other polyester fibres On 'Acrilan' polyacrylonitrile fibre, although 'Procinyl' dyes build up well to give heavy shades of very high wet-fastness, which results from the reaction between the dye and the basic groups in the fibre, only the yellow is of particular interest, the remaining dyes giving shades of low light fastness On acrylic fibres not modified by the incorporation of basic substances they display only limited build-up

British Ceramic Research Association

Mellor Library

The new library of the British Ceramic Research Association—the Mellor Library—was opened at Stoke-on-Trent on June 16 by Mr Frank West, vice-president of the Association and a lifelong friend of the late Dr J W Mellor, in whose honour the library has been named Dr Mellor, the well-known physical chemist, turned his mind to problems of the ceramic industry , Wedgwood, a century and a half previously, had transformed a craft into an industry , Mellor, during the first three decades of the present century, did outstanding service to that industry by giving it the basis of science that had hitherto been largely wanting As head of the Pottery Department of the North Staffordshire Technical College, Mellor taught a generation of pottery managers , as first director of research of the British Refractories Research Association (the forerunner of the British Ceramic Research Association) Mellor initiated research at a time when industrial research was a novelty But perhaps he is best known as the author of the "Comprehensive Treatise on Inorganic and Theoretical Chemistry"

Educational Research

The third issue of *Educational Research*, the journal of the National Foundation for Educational Research in England and Wales, contains articles on the teaching of mathematics, the ability to teach, the effect of environment on intelligence, school guidance services and a comparison of attainments in different types of primary school There is also a selected and annotated bibliography of works on the curriculum of the secondary school (Newnes Educational Publishing Co , Tower House, Southampton St , Strand, London, W C 2 5*s* 6*d*) In the article on the teaching of mathematics, Mr J B Biggs discusses the distaste for school mathematics so commonly reported His conclusions evaluate the relative effect of basic personality and specific likes and dislikes, particularly in the case of the maladjusted child Many so-called lazy children are seen to have found an initial block to their number learning because of their temperament This is heightened by accusations of laziness and consequent unimaginative driving by some teachers The implications of this and the other stimulating conclusions are important to the teacher who might well ask himself why there is no similar anxiety concerning English

A New Geological Documentation Service

The wealth of information available constitutes a serious problem for the future of the research in the Earth sciences Before 1939, published work could be covered by giving about one thousand references a month At present, the Service d'Information Géologique of the Bureau de Recherches Géologiques, Géophysiques et Minières indexes monthly more than 3,000 references, and it is estimated that 5,000 references should be given to ensure complete coverage of the field The situation is complicated by the number of works now appearing in little-known languages, and by the launching of new periodicals and special publications Faced with this problem, the Service d'Information Géologique of the Bureau de Recherches Géologiques, Géophysiques et Minières, which has taken over and expanded the work of the Centre d'Études et de Documentation Paléontologiques, has set itself the task of providing an extended and rapid service of basic geological information The Service d'Information Géologique scans every week about 3,500 periodicals, more than 200 of which are published in Russian The references are typed in the original language or, if they are not in Latin characters, are translated, usually into French , they are then classified in 1,200 sections under twelve main headings (mineralogy, petrography, stratigraphy, tectonics, geophysics, geological activities, geological phenomena, applied geology, general palæontology, biology, botany and zoology) The work is, of course, carried out under the supervision of scientists Each reference is indexed by title and by content The average number of indexes to each abstract card is five

Central Advisory Water Committee

On the expiry of the first period of appointment, the Minister of Housing and Local Government, Mr Henry Brooke, has reviewed the composition of the Central Advisory Water Committee and made various re-appointments and new appointments The membership of the Committee is drawn from the major interests concerned with water, for example, water supply, industry, scientists, agriculture, river boards The Minister is chairman of the Committee, and the vice-chairman is the Parliamentary Secretary, Mr J R Bevins Since its reconstitution in 1955 the Committee has published reports on the demand for water in England and Wales, on information on water resources and on the law dealing with the disposal of trade effluents

Seismological Association Meeting in Toronto

THE report of the meetings of the Section for Seismology and the Physics of the Earth's Interior, prepared by the associate secretary, Dr Markus Båth, of Sweden, has recently been published (pp 448 Strasbourg Bureau Central International de Séismologie, 1958) Most of the subdivisions into which this subject may be divided were discussed in the twenty-two sessions Detailed reports of these meetings, the presidential address by Prof K E Bullen, of the University of Sydney, the report of the meeting of the European Seismological Commission, the Committee of the International Seismological Summary and the Committee for the International Geophysical Year are included In addition, there are seismological reports from thirty-four countries, and the resolutions adopted at the assembly The whole covers some 455 quarto pages At the conference, ten sessions were devoted to seismology alone, six to joint meetings with the Association of Volcanology and two to joint meetings with the Association of Geodesy It was at an extra session at Toronto that Prof K E Bullen announced that the U S Atomic Energy Commission had released information concerning the time and place of a future underground nuclear detonation in Nevada, so that seismologists could prepare to participate in the recording The International Geophysical Year Committee discussed particularly the recording of earthquakes with epicentres in the arctic and antarctic regions , and it is noteworthy that M E Guyot is proceeding with the preparation of a seismological dictionary which it is hoped will be published without delay

Soil Survey of Great Britain

THE soil survey of Great Britain, with headquarters at Rothamsted, will occupy many years, and reports are to be published as each county is completed The magnitude of the task can be realized from the memoir on Anglesey (Agricultural Research Council Memoirs of the Soil Survey of Great Britain—England and Wales The County of Anglesey Soils and Agriculture By E Roberts Pp viii+116+11 plates London H M Stationery Office, 1958, 10*s* net), which includes also a small proportion of Caernarvonshire , nearly fifty soil series, which are the mapping units, are identified and described Anglesey is relatively flat, but there are considerable variations in the land surface due to the rugged outcrops of the Mona complex, the sharp escarpment of the Carboniferous limestones, the igneous rocks, wind-blown sands and glacial features The varying thickness of the boulder clay has contributed to the irregular undulations of most of the fields

Classification and mapping of the soils are based on the soil profile, since it reflects the action and balance of the many processes that have led to its formation , drainage has a profound effect, and is taken into account in the classification Although familiar to soil scientists and to many advisory officers, the subject is new to workers in related subjects, and to farmers The Soil Survey of Great Britain will be the foundation for a planned approach to fertilizer and cropping problems for many years, and such reports will have to be studied, and the maps referred to frequently The one inch to the mile soil map that is provided may prove too small for reference to some individual farms on or near the margins of the soil areas, but a 6-in map is available for reference at Rothamsted

Grassland Productivity

"The Measurement of Grassland Productivity" was the subject of the sixth Easter School in Agricultural Science which was held at the University of Nottingham School of Agriculture, Sutton Bonington, during April 13–16, and was organized by Prof J D Ivins Twenty papers were read, primarily concerned with techniques of grassland evaluation Assessment of productivity from the botanical point of view, in terms of animal production, the consumption of herbage by grazing livestock and grassland productivity on a farm scale were considered New varieties of herbage plants have been produced and their requirements have been explored to a great extent New techniques have been developed which have resulted in vast increases in the production from grassland, but a constant problem and hindrance to development has been—and still is—the lack of methods which may be used with validity to measure and compare grassland productivity Some 140 members from Britain and overseas exchanged experiences and ideas and discussed the limitations and applications of techniques of measuring the productivity of grassland The proceedings will be published

Safety in Mines Research

THE thirty-sixth annual report on Safety in Mines Research (pp 81+4 plates London H M Stationery Office, 1958 5*s* net) is a general review of progress in the year 1957 of the Safety in Mines Research Establishment of the Ministry of Power The report describes research undertaken in the general fields of explosives and blasting devices, explosion hazards, breathing apparatus, fire hazards, engineering and metallurgy, dust control and pneumoconiosis hazards, and in certain other fields, together with a record of testing services carried out by the Establishment A significant feature of some aspects of the work is the active co-operation and interchange of results with kindred establishments in France, Germany and Poland More than ninety topics are discussed , it is difficult to select individual topics for special mention, but perhaps attention may be directed to the work reported on the fluid mechanics of coal dust explosions, a subject of interest to all concerned with fires and explosions due to organic dusts There are, in fact, many topics reported which are of interest and importance to several industries in addition to the mining industry, including breathing apparatus, engineering and metallurgical problems of importance in conveying, winding and supports, and the study of dusts and of pneumoconiosis

Morbidity Statistics from General Practitioners

IN the series of Studies on Medical and Population Subjects, the first volume of morbidity statistics collected from general practitioners has recently appeared (General Register Office Studies on Medical and Population Subjects No 14 Morbidity Statistics from General Practice, Vol 1 (General) By Dr W P D Logan and A A Cushion Pp iv+174 London H M Stationery Office, 1958 15*s* 6*d* net) A number of practitioners agreed to keep records of all consultations with patients on their list, and the General Register Office went to considerable trouble to obtain the correct population at risk to which these consultations could be related While the practices were not chosen as a representative sample of the total population, this is the first time that a survey has been taken, and that data showing the load on general practitioners have become available on this scale The present publication shows consultation rates, and rates of patients consulting for different age and sex groups and different diseases It is expected that a further volume which will contain figures on occupational morbidity will be issued in the future

Mammals of the Belgian Congo

A PAPER by J Verschuren on the ecology and biology of the larger mammals of the Garamba National Park in the north-east of the Belgian Congo forms the ninth fascicle of the results of H de Saeger's expedition for the exploration of the park (Exploration du Parc National de la Garamba Mission H de Saeger Fascicule 9 Écologie et Biologie des Grands Mammifères (Primates, Carnivores, Ongulés) Par Jacques Verschuren Pp 225+2 planches Bruxelles Institut des Parcs Nationaux do Congo Belge, 1958) In the region studied the larger mammals are much more difficult to observe than in East Africa owing to the much denser vegetation in which they seek refuge, but the author has made good use of the two years that he was in the field and has collected much valuable information about their biology After a short introduction describing the country and the methods employed the work is arranged systematically, and each species is dealt with under the headings particulars of specimens examined, local names, geographical distribution, systematics and morphology, and ecology and biology. For most species the last section is by far the largest and is full of carefully recorded observations of the greatest interest. Fifty-one species are dealt with, distributed among the Primates, Pholidota, Carnivora, Tubulidentata, Proboscidea, Hyracoidea, Perissodactyla and Artiodactyla. The author adds that his lengthy experience of mammals in the wild has convinced him of the invalidity of many of the innumerable forms, subspecies, and races that have been so profusely described by some writers—a remark that will be heartily endorsed by other field zoologists The value of the paper is enhanced by a large number of photographic illustrations, including two plates in colour

Collision Broadening of Spectral Lines

COLLISION broadening is an important process in the formation of stellar absorption lines, and collision shifts have been discussed as a possible explanation of that part of the red shift of solar lines which is unaccounted for by the Einstein gravitational shift W R Hindmarsh (*Mon Not Roy Astron Soc*, 119, 11, 1959) has recently reported the results of the first of a series of measures of collision effects in atomic spectra The collision shift and broadening of the neutral calcium line λ 4227 A due to an external pressure of helium have been measured The line was formed in absorption by passing white light through calcium vapour in the presence of helium at various pressures less than one atmosphere The half-intensity damping width of the line was found to be 1 72 $\times$ 10^{-20} cm^{-1} per atom per cm^{3} of helium, and the shift 0 05 $\times$ 10^{-20} cm^{-1} per atom per cm^{3} towards the violet The ratio of broadening to shift on the Lindholm theory is 2 76, and the shift is predicted to be towards the red The observed ratio is much larger and the observed shift is in the opposite direction This discrepancy must be due to the involvement of the short-range repulsive forces between calcium and helium atoms as well as the long-range van der Waals forces Hindmarsh also shows that the collision shift of the calcium line is a negligible component of the solar red shift and cannot account for the difference between observed and predicted solar red shifts In the second paper following the above, W R Hindmarsh and K A Thomas show that for two argon lines the collision shifts are in reasonable agreement with the Lindholm theory

Hot Laboratory Equipment

"HOT Laboratory Equipment" is a revised and enlarged second edition of the "Hot Laboratory Catalogue", which constituted the major portion of "Chemical Processing and Equipment" (*TID*-5276), published by the U S Atomic Energy Commission as one of the several volumes for the 1955 International Conference on the Peaceful Uses of Atomic Energy The new edition (pp viii+429 Washington, D C Government Printing Office, 1958 2 50 dollars), which is fully illustrated contains descriptions of facilities, equipment and accessories for handling moderate to large amounts of radioactive materials It lists 229 items compared with 126 in the first edition, and includes newly developed items as well as items omitted for various reasons from the first edition Acknowledgment is made wherever possible to the organization responsible for the development of the particular equipment described Most of the equipment listed was developed by national laboratories or contractors to the Commission, but some were developed by private firms The contents is confined to hot laboratory equipment produced in the United States, but the reader is referred in the preface to two British publications ("Remote Handling Equipment", by A Apperly, Atomic Energy Research Establishment, *E/R* 1291, and "Radioisotope Instrumentation and Accessories", by D Taylor and A G Peacock, Scientific Instrument Manufacturers' Association, 1955) for information on similar equipment available in Great Britain

Textiles and Dyes at the University of Leeds

THE eighty-fourth report of the Textile Industries and Dyeing Advisory Committee on the work of the Departments of Textile Industries and Colour Chemistry and Dyeing in the University of Leeds (pp 47 Leeds The University, 1959) covers the session 1957–58, in which applications for admission greatly exceeded places and very full programmes of teaching and research were maintained In the Textile Industries Department, full-time students numbered 351 and in that of Colour Chemistry and Dyeing 50 Lists of publications are included In textile physics work continued in X-ray diffraction electron microscopy, infra-red absorption, and sedimentation in the ultracentrifuge A second electron microscope was installed In textile chemistry a method of producing a permanent lustre on all-wool fabrics has been developed and the chemical mechanism of permanent set especially that obtained with sulphite–bisulphite solutions, was re-examined Work on the effect of variations in the nature of the keratin in the assessment of wool quality continued The constitution of some suint pigments which may be involved in the staining of wool, the surface activity of steroids and pyrolytic degradation of cholesterol are being studied, and a brief examination of the dielectric properties of lanosterol indicated its suitability for use in impregnated paper capacitors

In textile engineering good progress is reported in the analytical study of loom noise and in a study of the drying of textiles In textile technology, work on the chemistry and practice of finishing fabrics made from both wool and man-made fibres continued and on the measurement of yarn irregularity The chemical properties of pigmented wool, the action of concentrated sulphuric acid on wool, the removal of compounds of high molecular weight from textile materials and the degradation and yellowing of nylon were also studied

In the Department of Colour Chemistry and Dyeing the course of the changes which occur in the reaction of aromatic carbonyl compounds with basic substances was examined, a study of stilbenequinone and its derivatives was completed, and work on elimination of groups from vat dyes on reduction and on the reactions of sulphinic acids with azo compounds and azines continued A group of diazonium salts soluble in benzene was prepared, and a study of the interaction of aminoanthroquinones and aminofluorenanes with nitrobenzene and α-nitronaphthalene was completed, as well as work on the vapour pressure and absorption energies of some anthroquinone and azo dyes The influence of the acetyl value of acetate rayon on the rate of dyeing and affinity for disperse dyes is being studied

Journal of Nutrition

Dr Richard H Barnes, dean of the Cornell University Graduate School of Nutrition, Ithaca, New York, has been appointed editor of the *Journal of Nutrition* He succeeds Dr George R Cowgill of the Yale Nutrition Laboratory, who has served as editor for twenty years Dr Cyril L Comar, director of the Laboratory of Radiation Biology, New York State Veterinary College, has been appointed associate editor The appointments became effective July 1, 1959 The editorial offices of the *Journal of Nutrition* are being moved from Yale University to the Cornell University campus Manuscripts should be sent to Dr Barnes at the Graduate School of Nutrition, Savage Hall, Cornell University, Ithaca, New York

Nature Conservancy Awards for 1959

The Nature Conservancy announces the following awards of research studentships for postgraduate training in ecology, tenable for periods up to three years at the universities shown *Botany* J K Marshall (Cambridge), D P Nicholas (Liverpool), W J Roff (Cambridge), J T R Sharrock (Southampton), D T Streeter (London), *Zoology* M L Clark (Leeds), E R Creed (Oxford), J M Edington (Durham), C J Henty (Oxford), J B Nelson (Oxford), G C Phillips (Oxford), *Geography* I G Simmons (London)

University News

Edinburgh

Prof A D Ritchie, professor of logic and metaphysics in the University of Edinburgh, retires on September 30, his long and distinguished career was mentioned in reviewing his recent book, "Studies in the History and Methods of the Sciences" (*Nature*, July 4, p 4) Prof E E Harris, formerly professor of philosophy in the University of the Witwatersrand, has been appointed acting head of Prof Ritchie's Department for one year

Swansea

The following appointments have been made in the University College of Swansea for the session 1959–60, Dr J R Cross, superintendent of the Chemistry Laboratories, Miss Glenys Thomas, map curator and cartographer in the Department of Geography, Mr P W Davies, assistant lecturer in metallurgy, Dr H E Evans, lecturer in engineering, Mr B W Preece, assistant lecturer in engineering

Announcements

Mr Walter Garner, formerly chairman of the Yorkshire Section and at present chairman of the London and District Section of the Textile Institute, and Dr A R Urquhart, honorary secretary of the Institute and an assistant director of the British Cotton Industry Research Association, have been awarded the Service Medal of the Textile Institute

Prof H Mark, director of the Polymer Research Institute of the Polytechnic Institute of Brooklyn, New York, will deliver the Fourth Baekeland Memorial Lecture under the title "Recent Progress in Polymer Chemistry" The Lecture will be delivered on October 22 at the Royal Institution, Albemarle Street, London, W 1

The International Commission on Zoological Nomenclature has been given accommodation in the British Museum (Natural History) This will greatly facilitate the work of the Commission by reason of the unique library facilities and wide range of specialist advice available Correspondence should in future be addressed to Mr N D Riley (Honorary Secretary), International Commission on Zoological Nomenclature, c/o British Museum (Natural History), London, S W 7

The second session (1959–60) of the Welsh Soils Discussion Group will open with a meeting in the Department of Agricultural Chemistry, University College, Bangor, on October 28 The subject for discussion will be "Mineralogical Aspects of Soil Science", the introductory speakers will be Dr F Smithson and Mr R I Davies (Bangor) and Mr. D F Ball (Nature Conservancy, Bangor) Further information can be obtained from Mr J A. Taylor, Geography Department, University College, Aberystwyth

The Scottish Conference on "Relationships in Industry Some Changing Concepts of Management", which is being organized jointly by the British Institute of Management and the Ministry of Labour, will be held at Gleneagles Hotel during October 23–24 It will be opened by Sir Alexander Fleck, chairman of Imperial Chemical Industries, Ltd Further information can be obtained from the British Institute of Management, Management House, 80 Fetter Lane, London, E C 4

In November 1859 Charles Darwin published "The Origin of Species" and Queen Victoria granted the Royal Title to the Royal Society of Victoria To mark these two centenaries, the Society is organizing a symposium on the Evolution of Living Species, to be held in Melbourne during December 7–11. Dr Ernest Mayr of the United States will be the guest speaker Further information can be obtained from the Honorary Secretary, Royal Society of Victoria, 9 Victoria Street, Melbourne, C 1, Victoria

Referring to the review in *Nature* of June 27, p 1766, Messrs Chapman and Hall state that the present American price of Cox's "Planning of Experiments" is 7 50 dollars

MOLECULAR AND ATOMIC MOTIONS BY RADIO-FREQUENCY METHODS

MAXWELL-AMP.E.R.E. CONFERENCE

A JOINT meeting of the Colloque AMPERE (Atoms et Molecules par Etudes Radio-Electriques) and the British Radio Frequency Spectroscopy Group was held during April 1–3 at Queen Mary College, University of London The meeting was attended by more than two hundred scientists, mostly from the British Isles but with strong representation from France, Holland, Switzerland and the Eastern European countries in particular The subject for discussion at the Conference was, "Molecular and atomic motions in liquids and solids by radio frequency methods" In the tradition of the AMPERE meetings the subjects covered were, dielectrics, nuclear magnetic resonance, quadrupole magnetic resonance and electron spin resonance. However, the range of the papers was constrained somewhat more than has been usual at the AMPERE conferences by the specification of a subject for discussion, albeit rather widely interpreted

The forty-four papers presented showed the power and range of the radio-frequency methods in studying molecular and atomic motion and there was an impressive consistency and similarity in the information produced by the very different experimental methods It was regrettable that time did not allow the inclusion of mechanical and ultrasonic absorption measurements although these received mention in several of the papers

Since many people versed in one discipline attended lectures in another, the occasion was a suitable one for having a general introductory lecture in each subject, and these were given by Prof. H Frohlich (Liverpool) on "Dielectric Theory", Dr J G Powles (London) on "Motional Effects in Nuclear Magnetic Resonance" and by Dr M Buyle-Bodin (Grenoble) on "Motional Effects in Pure Quadrupole Resonance" Even so, many of the discussions became extremely technical and specialized and the difficulty in having a meeting on a subject which cuts across the traditional interests and compartments of science was apparent This difficulty is a common one in conferences these days although highly specialized discussion is said to be evidence of 'maturity' of a subject It is regrettable that the cross-fertilization which should be brought about by conferences such as this one is so difficult to achieve It is therefore very valuable to have organizations 'd'informations mutuelles' such as the Colloque AMPERE and the British Radio Frequency Spectroscopy Group, the membership of which cuts across the traditional disciplines and contrasts with the extreme specialization of many organizations

It was a source of great sorrow to all present, and particularly to the writer, that Prof Freymann (Paris), the inspiration of the Groupement AMPERE, was unable to be present owing to illness, and that this should be the first AMPERE Conference he has missed

The conference overcame in large measure the difficulties occasioned by the fact that it was held outside France for the first time (apart from a foray to Geneva in 1957) and was well attended by French scientists Although some 50 per cent of the papers were presented in French, the British members appeared to survive the ordeal without severe discomfort, and it may be that the teaching of French in our grammar schools is not as ineffective as is commonly supposed. The language difficulty was lessened by the provision of pre-prints of most of the papers

It would obviously be impracticable to mention all of forty-four papers and a brief summary only will be presented in an attempt to give some idea of the scope of the conference

The conference was opened by Prof H Frohlich, who gave a masterly summary of the present situation in the theory of dielectrics, the main point of which was that the whole of the general theory has been worked out The continuing appearance of papers on 'general theory' are no more than mathematical exercises, and whether these results are correct or not they are irrelevant This point of view was undoubtedly novel to many present He elaborated his position by discussing the whole field of dielectric loss in which he distinguished four types all but one of which are well understood He was particularly concerned with the extent to which the theory can be dealt with macroscopically, which is of first importance because of the long-range nature of dipolar forces, and with the number of independent parameters required for an *understanding* of the phenomena involved He did point out nevertheless that a great deal of work remains to be done in the theory of dielectrics but that this should be concerned with the detailed interpretation, using models and so forth, and in the search for information about materials and processes

This lecture led on naturally to the more detailed discussion of a number of papers on dielectric loss in liquids and solutions, which depends in large measure on molecular properties and in which the 'model' aspect was very evident.

J D Hoffman (National Bureau of Standards, Washington) introduced a session on solids with an account of his work on systems having multiple relaxation times leading to bimodal, or even multimodal, loss curves which he explains in terms of multiple minima in the energy as a function of the orientation of a dipole A paper by H Granicher and C Jaccard (Zurich) summarized the present position in the interpretation of the dielectric properties of ice B Szigeti (Liverpool) described his recent work on a so far unobserved librational absorption process which should be found in crystalline long-chain substances

There were a number of papers on the dielectric properties of systems in which water or a gas was adsorbed on materials such as silica gel

The session on nuclear magnetic resonance was opened by J G Powles (London), who gave a summary of motional effects which can be studied by nuclear magnetic resonance, including numerous examples of the various types of effect which may occur He pointed out that examples of many of these would be found in the following papers but gave a number of extra ones in order to provide a balanced picture of the potentialities of the method

There were several papers on motional effects in hydrocarbons which were concerned with the elucidation of the molecular motions occurring in these molecular crystals. E. R. Andrew (Bangor) summarized his recent work on macroscopic motional effects, extending his considerations to quadrupolar effects and showing in particular how macroscopic motional experiments may help in deciding the nature of a magnetic interaction. A paper by K. Luszczynski (London) discussed the rather complex motional effects in the polymer poly*iso*butylene. J. A. E. Kail and J. G. Powles (London) had studied the molecular motion in *iso*butyl bromide, which is of interest since it is readily obtained either as a crystal or as a supercooled liquid over a wide temperature-range. The value of nuclear magnetic resonance measurements made at kilocycle frequencies was pointed out by G. Hochstrasser (Geneva). The interest in comparing nuclear resonance and self-diffusion parameters in mobile liquids of long-chain compounds was discussed by D. Cutler and J. G. Powles (London). M. P. McDonald (Heston) presented high-resolution results on amphiphilic solutions which have liquid crystal phases. D. J. Kroon and C. v. d. Stolpe (Eindhoven) reported nuclear resonance measurements which throw light on the movement of hydrogen in the alloy Th_2Al, which is used as a getter. H. Winkler (Leipzig) discussed the nuclear resonance of water sorbed on alumina, which links up nicely with the corresponding measurements reported in the Dielectrics Session by G. Ebert (Leipzig). I. Solomon (Saclay) reported a new method of measuring long nuclear resonance relaxation times.

The session on pure quadrupole resonance was opened by M. Buyle-Bodin (Grenoble), who gave an excellent summary of the motional effects which are to be found and included an appreciation of his own valuable contributions in this field. J. L. Ragle (Amherst, Mass.) reported work which indicated the motional effects in 1,2-dichloroethane. It was reported by F. Herlach, H. Granicher and D. Itschner (Zurich) that a new phase transition had been found in potassium iodate by nuclear quadrupole resonance, and the value of this method in detecting such 'weak' transitions was pointed out.

Time was then given to an informal discussion on commercial instrumentation in magnetic resonance. A number of firms briefly described their products and this was followed by a general discussion. The time and occasion were appropriate since the amount of commercial instrumentation available is at present rapidly increasing. It was of interest to note the great difference in tone and objectivity between a commercial and a scientific discussion.

In the session on electron spin resonance it was evident that motional effects are less important and appear very much as a by-product. D. J. E. Ingram, M. Fujimoto and M. C. Saxena (Southampton) reported experiments indicating two types of motion: one in which rate of radical diffusion in an organic glass could be measured, and another in which the spectrum differed with temperature, which was taken to indicate an effect due to reorientation of methyl groups within the radical. It was unfortunate that no paper was offered in which the motional averaging of the anisotropic hyperfine splitting was discussed. In a striking paper, K. H. Hausser (Heidelberg) showed how the resolution of hyperfine spectra in free-radical solutions depends on the optimum condition for observation of detail in the spectrum, which is essentially a motional effect and which must be arranged to give optimum relaxation parameters. Presumably motional effects can be studied in this way although this was not emphasized in the paper. A. Landesman (Saclay) reported a study of the $(SO_3)_2NO^{2-}$ ion in solution by measurement of the solvent protons.

During a session on motional effects in irradiated materials, J. S. van Wieringen and A. Kats (Eindhoven) reported paramagnetic resonance spectra of irradiated fused silica at liquid-nitrogen temperature which were due to hydrogen atoms formed from water impurities. The variation of these signals with temperature and time was used to study the motion of the hydrogen atoms. A. Losche (Leipzig) reported proton magnetic resonance measurements on nylon-6 which had been subjected to doses of comparatively weak γ-radiation over periods of several months. The radiation causes chemical changes which affect the molecular mobility of the polymer and hence the nuclear signals. It was suggested that this might be a suitable method of measuring integrated radiation doses when the intensity is rather low.

The papers presented at the conference, but not the discussions, are being published in a special issue of *Archives des Sciences* (price 25 Swiss francs). Copies may be obtained by writing to the Secretariat AMPERE, Institut de Physique, Bd. d'Yvoy, Geneva, Switzerland.

The next Colloque AMPERE will be held in Pisa, Italy, in September 1960. J. G. Powles

SEMICONDUCTING SILICON CARBIDE

One of the most important aspects of semiconductor physics in recent years has been the search for materials which yield devices capable of operating at higher temperatures than germanium and silicon. In this search, silicon carbide has been regarded as an important candidate, although, indeed, there are others. For silicon carbide, the high temperature of formation implies a high degree of stability at all temperatures likely to be encountered by devices. Moreover, the material can be regarded simply as silicon in which half the atoms have been replaced by the chemically similar carbon. In this way, much of the available information concerning, for example, the effect of impurities in germanium and silicon should be applicable to silicon carbide also, considering that the bonds are almost wholly covalent. Again, the relatively wide band gap would promise a large measure of electrical stability over a wide range of temperature. These advantageous features tend, unfortunately, to be balanced by a major practical difficulty, namely, that of growing single crystals with a controlled content of additives and crystal defects.

In order to explore these problems and to make a general assessment of our present knowledge, a major conference was recently held at Boston during

April 2–3, sponsored by the U.S. Air Force Cambridge Research Center and under the chairmanship of Dr. J. R. O'Connor. The U.S. Air Force Cambridge Research Center has for some time been the principal agency engaged on the task of initiating, supporting and co-ordinating a comprehensive research programme on silicon carbide, covering fundamentals and devices on a long-term basis. Forty-six papers were presented, dealing with such matters as the phase relations of the silicon – carbon system, methods of crystal preparation (by sublimation, gaseous cracking, epitaxial growth and from solution), silicon carbide as a solid (crystal structure, surface morphology, oxidation), silicon carbide as a semiconductor (band structure, electrical and optical properties) and silicon carbide devices.

Recent phase studies show that silicon carbide does not decompose thermally below 2,830° C., contrary to earlier reports. Large single crystals of the material have, of course, been available for a long time; but, as a rule, these appear only accidentally in the course of manufacture of silicon carbide in large furnaces which do not permit accurate control. In comparison, the laboratory methods listed above lead to crystals of much higher purity (for example, as assessed by neutron activation and spectrographic methods) but of very much smaller size. It has been widely suggested that the scale of the operation may have an important influence on the outcome and that, in any event, the temperature gradient in the direction of growth should be brought under control. Crystal growth from solutions of silicon or iron – silicon alloys supersaturated with carbon has yielded plates up to 8 mm. across and 0.5 mm. thick. The optimum growth conditions have not yet been determined. The structural studies are, of course, devoted to the well-known property of silicon carbide of forming a great variety of polytypes which are not yet fully understood. There is as yet no evidence of any definite connexion between polytype formation and impurity content, but interesting relationships are known to exist between the polytypic structure and the geometry of the spiral growth surfaces.

The width of the forbidden energy gap, derived from optical absorption measurements, has been found to be 2.86 eV. at 300° K., with a temperature coefficient of -3.3×10^{-4} eV./deg. C. The existence of impurity bands has been inferred from observations of electroluminescent spectra as a function of temperature and current density. The electroluminescence itself is now firmly believed to be due to the injection of minority carriers through *p–n* junctions and their subsequent recombination in luminescent centres, even though many details still remain to be clarified. An electron mobility of 32 cm.^{2}/volt-sec. has been quoted for material containing 10^{15} to 10^{17} donors/cm.^{3}

The question of departures from stoichiometry is still highly controversial. It is not yet known whether such departures exist to any significant extent and whether they lead to donor or acceptor formation if they do. The minority carrier lifetime, measured by observing the photoconductive decay following the cessation of an optical stimulus, is very short but can reach a few tenths of a microsecond. This fact, coupled with the relatively small carrier mobility, makes the design of silicon carbide transistors a problematical prospect. It is, however, believed that such transistors, whether unipolar or bipolar, could now be made if the best available crystals were used in conjunction with the most sophisticated micromanipulation techniques. In practice, gallium phosphide, with its lower melting-point (~ 1,340° C.), wide band gap (2.25 eV.) and higher carrier mobilities may prove to be an important competitor. Apart from this, there are fair prospects for device applications in the field of high-temperature rectification. *p–n* junctions can be prepared by the usual doping techniques and a finished encapsulated rectifier capable of operation at 500° C. was described. The more familiar application of silicon carbide for the manufacture of non-linear current devices ('varistors') is still of great interest. The behaviour of these devices is now reasonably well understood, even though the detailed circumstances may be complicated by thermal effects, impact ionization and the current-dependent charges in intergranular surface states.

The proceedings of the conference were summarized by a review panel under the chairmanship of Dr. W. Shockley. They will be published in book form by Pergamon Press.

H. K. HENISCH

AVAILABILITY OF PLANT NUTRIENTS

A MEETING of the British Society of Soil Science held, by kind permission, at the London School of Economics on April 9, was devoted to consideration of the factors which determine the availability of nutrients in the soil. Five papers were presented and discussed.

Dr. R. K. Schofield (University of Oxford) referred to the successive stages in transfer of nutrients from the soil surfaces, through solution to the roots where metabolic assimilation takes over; any one stage may provide a limiting factor in the supply to the plant and the problem is to unravel their relative importance. Extraction with a weak electrolyte such as calcium chloride goes some way towards characterizing the intensity factor of phosphorus in the soil, but use of phosphorus-32 and calcium-45 has given a better understanding of the labile pool of these nutrients and a measure of the capacity factor. The low concentration of phosphorus extracted by calcium chloride compared with the amount isotopically exchangeable suggests that the time of transit between absorption sites is small. Uptake by roots introduces another factor, but pot experiments with cabbages, barley and lupins using phosphorus-32 showed no differences in the supplies accessible to these plants. Judged by the specific activity of the phosphorus in the plants and in various soil extracts, calcium chloride solution or water gave a better assessment of availability than did many of the solutions often used in soil analysis; these liberated phosphorus which was not available to plants.

Dr. P. Newbould (University of Oxford) described experiments with calcium-45 uniformly mixed with two soils in pots. The specific activity of calcium absorbed by barley and ryegrass fell steadily during growth owing to a slow equilibration with forms of calcium other than exchangeable calcium. As roots locally depleted supplies of labile calcium, more calcium came into circulation. Exchangeable and available calcium can no longer be regarded as synonymous, and the latter is affected by the activities of plant roots.

Dr. R. Scott Russell (Agricultural Research Council Radiobiological Laboratory) directed attention to different steps in nutrient absorption by roots and stressed that the effective area of absorption was restricted to a region near the apices. The availability of a nutrient to a plant may be influenced by interactions with other ions either by competition or by physiological changes. Dr. Scott Russell referred to work which suggested that the individual root-absorption characteristics of different crops influenced the apparent availability of a nutrient such as phosphorus in a soil.

The probable parts played by micro-organisms were described by Mr. J. S. Waid (Levington Research Station, Ipswich), who stressed that much of the evidence was circumstantial and required further substantiation. Organisms are known to be able to increase the water solubility of nutrients by oxidation or reduction, and by the decomposition of organic materials; the availability of nitrogen is intimately bound up with biological processes. Soil organisms may compete with roots for soluble nutrients especially when stimulated by supplies of organic materials, some of which may be provided by the roots themselves; production of carbon dioxide or toxins may affect the physiological activity of plant roots.

Dr. G. W. Cooke's paper (Rothamsted Experimental Station) described the problems of assessing the nutrient status of a soil for advisory purposes; here the criterion is the probable economic response of various crops to fertilizer dressings, and in this field soil analysis has not made much progress. The results generally distinguish between the broad levels of nutrient status for phosphorus and potassium, but in order to avoid crop failure in the exceptional cases the overall application of these fertilizers is about double the amount that is economically justified. The assessment of the nitrogen status of soils is even more uncertain, and there is an acute need for the development of fresh analytical techniques tested against field trials. Dr. Cooke suggested that a more successful approach might lie in the use of soil analysis for 'fertility control' whereby a record was maintained of the fertility status of a soil so that warning was given of abnormalities before they became acute.

In the open discussion which followed these papers the following points were among those made:

Correlation between soil analyses and field responses is poorer in tropical and other under-developed areas than it is in Britain, yet the need for reliable soil tests is even greater. Different speakers stressed the importance of studying the anomalous soils in order to discover which factors affecting the availability of nutrients have been neglected. Analysis should not be divorced from examination of profiles since often these showed some physical property which meant that, while nutrients might be available in the chemical sense, they were inaccessible to plant roots.

The value of plant analysis in relation to fruit crops and forestry was mentioned; by this means it may be easier to recognize an interaction effect which is not revealed by soil analysis. Some progress was also reported on the development of techniques for determining the nitrogen status of soils; this seems to be greatly affected by re-wetting of air-dry samples.

D. V. CRAWFORD

AHMEDABAD MILLOWNERS' TEXTILE INDUSTRY'S RESEARCH ASSOCIATION

A TEXTILE research laboratory, created and sustained by the co-operative effort of the industry and the Government of India, was envisaged by the Ahmedabad Millowners' Association as early as 1944. In 1947, the Ahmedabad Textile Industry's Research Association was registered with a membership of seventy-one mills. Ahmedabad thus became the proud pioneer in establishing a co-operative research centre for the cotton textile industry in India.

The Association started functioning in 1949, and its impact was soon felt by the industry in and around Ahmedabad. It became clear to the original members that the benefits accruing from research could with advantage be placed at the disposal of the industry on a nation-wide basis. With this object in view, the constitution of the Association was suitably amended so that mills outside Ahmedabad could become members and enjoy the same research benefits as the original founders. The present strength of members including all categories stands at eighty-eight mills and allied concerns, comprising thirty lakhs of spindles and sixty-three thousand looms—roughly one-third of the Indian cotton textile industry.

The policies of the Association are decided by an autonomous body known as the Council of Administration. At present, the twenty-member Council is made up of representatives of management, nominees of the Government of India, the director and secretary of the Association as well as directors of other research organizations, and co-opted scientists. The Textile Commissioner is one of the nominees of the Government of India. Shri Kasturbhai Lalbhai has been the chairman of the Council from its inception.

The composition of the Council ensures a balanced and co-ordinated research policy which takes into account similar efforts by other textile research institutions and national laboratories. Further links with Government and with national research in related spheres have been established through the Ministry of Scientific Research and Cultural Affairs.

The Association began modestly in 1949 in three rooms in the Mafatlal Gazalbhai Science Institute. The foundation stone of the present building, which is housed on a 50-acre campus to the west of Gujarat University, was laid by Sardar Vallabhbhai Patel in November 1950. The building was completed towards the end of 1953 and formally declared open by Shri Jawaharlal Nehru in April 1954.

The laboratories of the Association are equipped with instruments for research in textiles and allied fields. Some of these instruments have been designed and fabricated there The physics laboratory has equipment for studying the structure and physical and mechanical properties of fibres, yarns and fabrics The chemistry laboratory has, in addition to the usual facilities for analysis of textile materials, a unit processing section equipped for the treatment of samples of yarns and fabrics through processes such as bleaching, dyeing, printing and finishing The pilot mill is a versatile unit and its machinery offers a wide range of processing sequences in spinning, weaving and chemical processing The workshops are equipped for the dual purpose of servicing mill machinery and of designing, fabricating and servicing laboratory instruments.

The Association owes its success in large measure to the enthusiasm of its workers Most of these workers have been recruited from universities and initiated into specialized fields of industrial research When necessary, training has been supplemented by periods of study in overseas institutions Technical assistance schemes such as the Point Four Programme, the Colombo Plan and the Imperial Chemical Industries Fellowships have been of great value. From a small group of about twenty-five workers in 1949, the Association has developed into an organization with a total strength of 200, which is made up of 75 scientists and technologists, 25 administrative workers, 40 skilled operatives and 60 service personnel

The services of a number of foreign specialists have been secured from time to time with the assistance of organizations like Unesco and the International Labour Organization, in 1956 the Association was recognized by Gujarat University as a teaching centre for postgraduate research At present most of the research students are awarded scholarships or fellowships by the Government of India, the Council of Scientific and Industrial Research, Gujarat University and the Association

In a technologically under-developed country, it is often the path of least resistance to apply to one's own use the findings of more advanced countries During the early days, the Association emphasized the application of scientific and technical knowledge already available to the problems of the industry This practice of helping the industry to implement the findings of research has paid rich dividends and constitutes one of the main activities of the Association at present In the process, industry has become wide awake to the potentialities of original research and has cordially welcomed the Association's efforts

While being primarily a research organization the Association tries to help industry in other ways Training in various skills, such as management and supervision, statistical methodology and testing procedures, is given to the staffs of member mills Such trained personnel not only become better equipped for their work, but also help in securing more effective implementation of the Association's programmes Often, they form the nucleus of research and training groups in their own organizations

GLASSHOUSE CROPS RESEARCH INSTITUTE

THE annual report of the Glasshouse Crops Research Institute for 1957* shows that, although full facilities are not yet available, the physical development of the Institute has made good progress and some of the major problems associated with commercial glasshouse practice have been investigated Physiological studies of the growth of tomatoes have continued, and practical problems of plant spacing and pruning have received attention Previous studies at Cheshunt and the Institute have shown that retention of lateral branches below the first truss, on widely spaced plants, of the variety 'Potentate' gave a yield nearly three times as great as on single-stemmed plants It was of importance to discover whether this constituted an increase in yield per unit area of glasshouse space, the factor of most concern to the grower This has been investigated in preliminary experiments by comparing the yields from plants having no side shoots and plants in which side shoots below the first truss had been allowed to develop Three different spacings between the rows were used The greatest yield per unit area was obtained from single-stemmed plants at the two closest spacings, namely, 2 ft and 3 ft, although multistemmed plants at 3 ft and 4 ft spacings had the greatest mean weight of individual fruit No treatment had any effect on weight per unit area of early fruit

A review of the literature on spacing of tomato plants in commercial cultivation, included in the report, shows that there is no simple answer to the question of optimal planting density for maximum yield It is thought that this may be because insufficient attention has been given to possible interactions between planting density and watering and manuring The study of the composition of the tomato fruit has been continued by the Chemistry Department, especially in relation to variety and state of ripeness of the fruit, with special reference to fruit quality and ripening disorders. It was concluded that the latter, evident by their effects on the outer fruit wall, were also related to the composition of the inner portion of the fruit Further investigations were made of the changes during ripening The acidity in the wall increased from the green stage to the first appearance of yellow pigmentation, but there was no consistent trend as ripening proceeded This was in contrast to the situation in the inner portion of the fruit, where acidity decreased and sugars (mainly glucose and fructose) increased The concentration of soluble solids in the expressed sap of the tomato varies considerably in relation to fruit quality and variety These investigations will be facilitated by the demonstration that measurement of refractive index by a simple hand refractometer gives a reliable indication of total dissolved solids

Work on urea–formaldehyde compounds as slow-acting nitrogenous fertilizers has been concluded, and a report gives the relative merits of the several compounds tested Liquid feeding of tomatoes is of considerable topical interest, especially in connexion with automatic irrigation, and research on this problem has been resumed Magnesium deficiency in glasshouse tomatoes is common, and preliminary results indicate that foliar sprays containing magnesium are more effective than soil treatments in maintaining normal leaf colour The plant-breeding programme is concerned mainly with improvements of tomato, cucumber and lettuce

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* Glasshouse Crops Research Institute Annual Report 1957 Pp 161 (Littlehampton Glasshouse Crops Research Institute, 1958) 10s

The investigations on *Didymella* stem rot of tomato have been continued by the Plant Pathology Department, which is also concerned with powdery mildew of cucumber and wilt disease of carnation as well as mushroom diseases Some experiments were carried out on chemotherapeutic control of tobacco mosaic virus in the tomato, but it was concluded that this approach is not promising Although insecticides properly applied should give adequate control of white fly, there are sometimes risks of chemical injury to plants, and for this reason interest has been revived in the method of biological control by wasp parasites The Entomology Department has begun a series of studies on the effects of environmental factors on the fecundity and development of white fly and on the host/parasite balance Other investigations by this Department include mushroom pests and the red spider mite The Crop Protection Department is concerned with the control of mildew of chrysanthemums and aphids on lettuce and with the residual toxicity of certain sprays

E C HUMPHRIES

RADIOLOGICAL HAZARDS TO PATIENTS

AT the end of 1956, the Secretary of State for Scotland and the Minister of Health appointed a committee "to review the present practice in diagnostic radiology and the use of radiotherapy in non-malignant conditions, having regard to the report of the Committee on the Hazards to Man of Nuclear and Allied Radiations"

This committee, under the chairmanship of Lord Adrian, has now produced an interim report (Ministry of Health, Department of Health for Scotland Radiological Hazards to Patients Interim Report of the Committee Pp 22 London H M Stationery Office, 1959 1*s* 3*d* net) for the one completed part of its survey, namely, the use of X-rays for mass miniature radiography The conclusion is drawn that, when properly conducted, examinations by this method make a negligible contribution to the total radiation to which the population is daily exposed Even on the most pessimistic assumptions, the indefinite continuation of mass miniature radiography at the present rate could add no more than 20 cases of leukæmia to the annual incidence of 2,500 cases in Great Britain, it is also possible that it would produce no additional cases at all The gonad doses, which determine the long-range genetical damage, have been found to be even smaller than previously estimated These very small somatic and genetical risks have to be considered in relation to the undoubtedly large benefits of mass miniature radiography to the health of the population In 1957, these examinations led to the discovery of nearly 18,000 cases of pulmonary tuberculosis and some 63,000 other abnormalities, which included lung cancer, heart disease and pneumoconiosis For children and pregnant women, mass miniature radiography is not recommended and should be replaced by normal radiographic procedures with strict limitation of the field to the chest Some general principles are also given for reducing unnecessary exposure in other forms of diagnostic radiology, in particular fluoroscopy, but the survey of this area is not yet completed

There is one statement in the introduction (paragraph 10) which may give rise to serious misunderstandings It is stated, correctly, that a dose of radiation which would double the present mutation-rate would cause perceptible damage to the population, and that this dose is estimated to lie between 10 and 100 r per generation It is also correct to say that at present the dose due to medical radiology does not exceed 3 rads per generation But it is only for the sake of convenience that genetical damage is usually estimated in terms of the 'doubling dose' There is no lower threshold to the genetical effects of ionizing radiation, and serious genetical damage will be produced already by doses which are far below the doubling dose In fact, the report of the Medical Research Council came to the conclusion that, from the point of view of genetical hazards, "the upper limit, which future knowledge may set to the total dose of extra radiation which may be received by the population as a whole, is not likely to be more than twice the dose which is already received from the natural background, the recommended figure may indeed be appreciably lower than this" On this evidence, the danger limit has already been reached or even exceeded in countries where X-rays are used extensively for medical purposes Against this damage to future generations we must, however, set the benefit to the present one and, although all means must be used to cut down avoidable exposure to radiation, a high amount of exposure will remain unavoidable if the present standards of medical service are to be maintained

FEEDING THE HUNGRY

THE practical way to wage war on want was the theme of an outstanding address at St John's College, Annapolis, Maryland, on April 9 by Mr Gerard Piel, publisher of *The Scientific American* Following an account of the way in which science has given man unlimited power and opportunities to change the material conditions of life, Piel shows how it is now possible to bring the elimination of want within the reach not only of the present generation but also of all future generations Want is no longer a challenge to technology, but to economics and politics, it is a social problem Thanks principally to the control of mortality, the under-privileged peoples are living longer and feeling well enough to do something about their plight These aroused people are still extracting the irreplaceable resources of their lands to feed the voracious appetite for raw materials of Western peoples At present the

United States imports from overseas iron ore, bauxite, oil and a host of commodities in greater volume than ever before. In some American sectors the technology is perilously dependent upon riches supplied so cheaply. The goodwill and compliance of the natives have immediate relevance to the American price structure.

It is impossible to stop at the churlish counsel that the Colonials should reduce their numbers. Their population is rising because the modicum of sanitation introduced to protect white Colonials in their midst has reduced their rate of mortality as well. Their numbers are increasing, according to United Nations studies, at a rate that exceeds 1 per cent per annum. Since the end of the Second World War their material condition has been in corresponding decline , their calorie intake has actually fallen.

To offset the claim of population growth and reverse the decline in their condition, they must increase their production at a rate greater than their population growth. The larger the differential, the faster will their lot improve. Such an objective is not only technologically but also politically and economically feasible. American industrial growth has averaged 5 per cent over long periods , it has reached 8 per cent under intense pressure. The growth of agricultural output has correspondingly proceeded at the rate of 2 per cent in normal times. In response to the economic cycle and to controlled prices and other regulatory devices, it fluctuates over an even wider range. The present curtailment of grain production in the United States represents 200,000 tons, which approximates to the calorie deficit for the underfed portion of the world population.

About 500 billion dollars over the next fifty years would secure an average gain per annum of 2 per cent in industrial production and a corresponding increase in agricultural output in non-Western areas. Not all the 500 billion dollars would have to be supplied from outside. At about the halfway point the new industrial centres would begin to generate some additional capacity of their own.

Bed-rock investments, however, are not particularly attractive to the world's capital market. These involve such elementary public utilities as communication systems, including highways as well as railroads, and dams for flood control and irrigation. Investments in such projects call for the kind of funds now written off on armaments. A long-range view should be taken in looking for return on investment.

Western technology is specially qualified to contribute to the soaring demand for electrical energy which will attend industrialization programmes. But the demand for huge volumes of energy, heavy equipment and big investment would not come at the outset. First, there is need for planning and, then, engineering. Many of the early gains in these areas would be achieved with very little expenditure on capital goods. The first requirement is for brains and knowledge.

An example of what can be accomplished is furnished by Mexico. For the past twenty years the Rockefeller Foundation has been working with the Ministry of Agriculture and Animal Husbandry of Mexico. At a cost of less than 2 million dollars a year, American agronomists have been supplied to Mexico, and young Mexicans have been trained in the agricultural sciences. In this period, the food production of the country has risen 80 per cent. The gains have been achieved by improved yields of Mexico's own staple crops, the development of new varieties of wheat and potatoes and the establishment of something like the American county-agent system for farmer education. Not a single tractor or fertilizer plant is in the expense account , the money has been spent on the intangibles of information, education and expert consultation. The 4 per cent per annum gain safely exceeds the 3 per cent increase in population and has brought an improvement in the people's diet which is already showing up in vital statistics.

Somewhere in American material and intellectual resources the capacity to expand on this precedent could be found. If a beginning could be made, it would soon be possible to have additional wealth and brains available for the task as a result of the attenuation of the arms race on which prosperity now rests so heavily and insecurely.

SYMPATHETIC POSTGANGLIONIC MECHANISM

By Prof. J. H. BURN, F.R.S., and M. J. RAND
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DURING recent years it has been demonstrated that acetylcholine exerts an action in various organs similar to that of sympathetic stimulation. Since this action is seen in the presence of atropine and is also exerted by nicotine, it follows that the action is not a muscarinic but is a nicotinic action. An example of this action is the contraction of the arrectores pili muscles in the skin of the cat's tail. This was first described by Brucke[1] for acetylcholine, and a few years later by Coon and Rothman[2] for nicotine. Most of the hair was removed from the cat's tail except for a few tufts, and acetylcholine or nicotine was injected into the skin at the base of the tufts. Pilo-erection was then observed. Normally the pilomotor muscles are caused to contract by sympathetic stimulation, and they also contract after the intravenous injection of adrenaline or noradrenaline. Other examples of sympathomimetic effects caused by acetylcholine or by nicotine in the presence of atropine are the relaxation of the isolated intestine of the kitten by nicotine[3] , the acceleration of the isolated atria of the rabbit[4] and the constriction of the vessels of the perfused rabbit ear by acetylcholine and by nicotine[5], the contraction of the isolated nictitating membrane of the cat by nicotine[6]. de Burgh Daly and Scott (unpublished work) have observed that acetylcholine injected into the splenic artery during perfusion of the spleen with blood caused contraction of the spleen. We are grateful to them for allowing us to quote this result.

These nicotine-like effects of acetylcholine, exerted at sites peripheral to sympathetic ganglia, thus resemble the effects of sympathetic stimulation, they are not seen in preparations from animals treated with reserpine. Tissues innervated by sympathetic nerves were found by Schmiterlow[7] and by Euler and Purkhold[8] to contain noradrenaline together with a much smaller amount of adrenaline. After treatment of rabbits with reserpine, the noradrenaline which can be extracted from the heart disappears[9]. Similarly after treatment with reserpine, the noradrenaline disappears from the aorta of the dog and of the rabbit, from the skin of the rabbit's ear and from the skin of the cat's tail, from the cat's spleen and from the iris of the cat's eye[10].

The nicotine-like actions of acetylcholine are also lost when the sympathetic fibres degenerate, and this degeneration is also accompanied by a loss of the noradrenaline which can be extracted from the organ[8,10b].

The conclusion may therefore be drawn that the nicotine-like actions of acetylcholine which have been described are due to the release of noradrenaline (possibly with adrenaline also) from the organ.

At present we are uncertain of the location of the noradrenaline in the organ. v. Euler[11] believes that it is contained within the postganglionic fibres, calculating that the amount may be 3–30 mgm./gm. This is one thousand times more than that in postganglionic fibres before they reach the organ. This amount is only of the order of 15 μgm./gm. The disappearance of the noradrenaline after degeneration of the nerves is readily explained if it is present in the nerves.

There is some evidence, which as yet is only suggestive, that the noradrenaline and adrenaline in the organs might be present in cells containing chromaffin granules. Such cells have been described in human skin by Adams-Ray and Nordenstam[12], and also by Burch and Phillips[13]. They have been found in the skin of the rabbit's ear, in the skin of the cat's tail and in the nictitating membrane. The chromaffin granules are greatly reduced or disappear in the tissues of animals treated with reserpine, or in tissues in which the sympathetic fibres have degenerated[10a,c]. Thus it is possible that the nicotine-like actions of acetylcholine are due to the release of noradrenaline and adrenaline from cells containing chromaffin granules. However, Muscholl and Vogt[14] have found that reserpine depletes the noradrenaline stores in the sympathetic neurones more readily than those in chromaffin cells.

Tyramine is a sympathomimetic amine which ceases to act after degeneration of the sympathetic fibres[15]. Its pressor action is also absent in the cat previously treated with reserpine[16]. The conclusion may be drawn that tyramine exerts its action by liberating noradrenaline and adrenaline from the store in the organ. Since an infusion of noradrenaline into the vein of a cat or into the blood perfusing the hind-leg of a dog increases the pressor and constrictor action of tyramine, or restores it when it is absent due to previous treatment with reserpine, it appears that the store of noradrenaline in the organ can be increased by taking up noradrenaline from the blood stream[17].

The effect of sympathetic stimulation also is increased as a result of an infusion of noradrenaline. If the volume of one hind-leg of a dog is recorded in experiments in which the lumbar sympathetic chain is stimulated, then, atropine having been given, the threshold strength of stimulus for causing vasoconstriction in the hind-leg can be determined. Following an infusion of noradrenaline, the total amount given to the dog being 0.2–1.0 mgm. in the course of 20 min., the threshold has been observed to fall to a mean of 40 per cent of its previous value. In experiments in which the dog's hind-leg has been perfused it has been observed that the effect of a given sympathetic stimulus was greatly increased. These observations indicate that the efficiency of sympathetic stimulation depends on the amount of noradrenaline in the neighbourhood of the nerve endings. This may be taken up from the blood into the nerve endings themselves or into chromaffin cells; one of the functions of the noradrenaline secreted by the adrenal medulla may be to fill up this store.

We have now considered evidence that the nicotine-like actions of acetylcholine are due to the release of noradrenaline from a store near the sympathetic nerve endings; we have seen that this store can take up noradrenaline which is circulating in the blood, and we have seen that the effect of sympathetic stimulation depends on the size of this store. We now turn to the sympathetic impulses themselves.

When a cat is treated with reserpine with the result that the stores of noradrenaline and of adrenaline are depleted, the effect of tyramine on the nictitating membrane is completely absent, but stimulation of the postganglionic sympathetic fibres still causes a contraction. The threshold strength for this effect is greater than the threshold in the normal cat. We have found that the contraction produced is augmented by eserine and is abolished by atropine, and the contraction must therefore be due to the release of acetylcholine from the sympathetic fibres. The presence of cholinergic fibres in the sympathetic supply to the nictitating membrane was suggested by Bacq and Fredericq[18]. Recent work shows that the presence of cholinergic fibres is still more widespread. Thus Gillespie and Mackenna[19] have found that when a rabbit is treated with reserpine, the isolated colon is caused to contract by sympathetic stimulation instead of to relax, and that the contraction is abolished by atropine. They concluded that cholinergic fibres are present in the sympathetic supply.

Huković[20], working in this Department, has made an isolated preparation of rabbit atria with the sympathetic nerves attached; when the sympathetic fibres from the stellate ganglion were stimulated the rate and amplitude of the atrial beat increased. If the rabbit was treated beforehand with reserpine some preparations responded to sympathetic stimulation by inhibition, the inhibitor effect being increased by eserine and abolished by atropine. This result suggests that cholinergic fibres are present in the sympathetic supply from the stellate ganglion to the atria.

Observations have also been made on the cat spleen, recording the changes in volume of the spleen by a plethysmograph. The nerves were separated from the splenic artery near the beginning of the artery. Stimulation caused contraction of the spleen which was unaffected by atropine. When the cat was treated beforehand with reserpine, it was found that in some preparations acetylcholine caused a dilatation of the spleen, and that stimulation of the nerves was also followed by dilatation. This dilatation was increased in the presence of eserine and abolished by atropine. Thus the splenic nerves also contain cholinergic fibres. Observations have also been made on the virgin cat uterus, recording its contractions *in situ* under chloralose anæsthesia. When the hypogastric nerves were stimulated, inhibition followed. When the cat was treated beforehand with reserpine, stimulation of the hypogastric nerves caused a small contraction which was greater in the presence of eserine and which was abolished by atropine. The evidence suggests that the hypogastric nerves contain cholinergic fibres.

The observations that the nicotine-like effects of acetylcholine resemble those of sympathetic stimulation, and that these effects are exerted by the release of noradrenaline (or adrenaline), must now be put side by side with the evidence of the existence of cholinergic fibres in postganglionic sympathetic fibres in various places where they were not suspected. It then appears that such cholinergic fibres may be adrenergic in their effect, because the acetylcholine which they liberate will cause the discharge of noradrenaline or of adrenaline from the peripheral store. The stimulation of such fibres can in theory have two effects, one, normally much the smaller, due to the direct action of the acetylcholine released, an action which is sensitive to atropine, and the other, normally much the greater, due to the released acetylcholine causing a discharge of noradrenaline from the store, a nicotine-like action not affected by atropine. This double effect may actually be present in the nictitating membrane, where the response to postganglionic stimulation in the normal cat is slightly diminished by atropine, for example to about 80 per cent of its initial size.

Such a double effect might explain the response to stimulation of the sympathetic supply to the muscles of the dog's hind-leg, where Burn[15b] observed that a stimulus for 3 sec. caused dilatation, while the same stimulus applied for 30 sec. caused in the main constriction. A double effect is possible only when acetylcholine has a direct muscarinic action of its own. Thus in the cat treated with reserpine, stimulation of the sympathetic fibres has no pilomotor effect in the tail. The accumulated evidence thus requires consideration of a new possibility. The adrenergic sympathetic fibre has been thought of as liberating noradrenaline in the same way as cholinergic fibres liberate acetylcholine. However, cholinergic fibres, which seem widespread in the postganglionic sympathetic supply, may liberate noradrenaline from the store at the nerve endings, and thus be adrenergic in effect.

In this account we have kept open the possibility that noradrenaline may not always be the main component of the peripheral store and that around some sympathetic nerve endings, in the virgin cat uterus, for example, adrenaline may be more important. We have no evidence on this as yet. We may also recall that Pines[21] has described the chromaffin cells in sympathetic ganglia and has given a detailed account of his findings that they are innervated.

[1] Brucke, F. v., *Klin. Wschr.*, 14, 7 (1935).

[2] Coon, J. M., and Rothman, S., *J. Pharmacol.*, 68, 301 (1940).

[3] Ambache, N., and Edwards, J., *Brit. J. Pharmacol.*, 6, 311 (1951).

[4] Kottegoda, S. R., *Brit. J. Pharmacol.*, 8, 83 (1953).

[5] Kottegoda, S. R., *Brit. J. Pharmacol.*, 8, 156 (1953).

[6] Thompson, J. W., *J. Physiol.*, 141, 46 (1958).

[7] Schmiterlow, C. G., *Acta Physiol. Scand.*, 16, Supp. 56 (1948).

[8] Euler, U. S. v., and Purkhold, H., *Acta Physiol. Scand.*, 24, 218 (1951).

[9] Bertler, A., Carlsson, A., and Rosengren, E., *Naturwiss.*, 43, 521 (1956).

[10] (*a*) Burn, J. H., and Rand, M. J., *Brit. Med. J.*, i, 903 (1958); (*b*) *J. Physiol.* (in the press). (*c*) Burn, J. H., Leach, E. H., Rand, M. J., and Thompson, J. W., *J. Physiol.* (in the press).

[11] Euler, U. S. v., "Noradrenaline" (C. C. Thomas, Springfield, U.S.A., 1956).

[12] Adams-Ray, J., and Nordenstam, H., *Lyon chir.*, 52, 125 (1956).

[13] Burch, G. E., and Phillips, J. H., *Circulation Res.*, 6, 416 (1958).

[14] Muscholl, E., and Vogt, M., *J. Physiol.*, 141, 132 (1958).

[15] (*a*) Burn, J. H., and Tainter, M. L., *J. Physiol.*, 71, 169 (1931). (*b*) Burn, J. H., *J. Physiol.*, 75, 144 (1932).

[16] Carlsson, A., Rosengren, E., Bertler, A., and Nilsson, J., 'Psychotropic Drugs" (Elsevier Publishing Co., Amsterdam, 1957).

[17] Burn, J. H., and Rand, M. J., *J. Physiol.*, 144, 314 (1958).

[18] Bacq, Z. M., and Fredericq, H., *Arch. Int. Physiol.*, 40, 297 (1935).

[19] Gillespie, J. S., and Mackenna, B. R., *J. Physiol.* 147, 31*P* (1959).

[20] Huković, S., *Brit. J. Pharmacol.* (in the press).

[21] Pines, I.-L. J., *Arch. Psychiat. Nervenkr.*, 70, 636 (1924).

PROTEIN BIOSYNTHESIS AND OXIDATIVE PHOSPHORYLATION IN ISOLATED RAT LIVER MITOCHONDRIA

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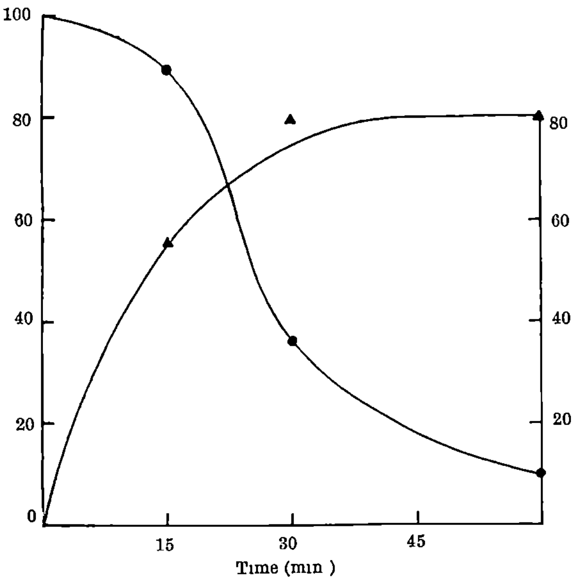
ELECTRON microscopy combined with differential centrifugation of sucrose homogenates has shown that liver parenchymal cells have a complex cytoplasmic structure[1]. After intravenous injection of amino-acids labelled with carbon-14 the proteins of the subcellular cytoplasmic structures of these cells become labelled at different rates. In both rats and guinea pigs the liver microsomal fraction is labelled considerably more rapidly than the mitochondrial material. Labelling is particularly rapid in the ribonucleoprotein fraction of the microsomes[2]. The suggestion has been made that protein synthesis takes place mainly in the microsomal ribonucleoprotein fraction and that mitochondria acquire radioactive protein from the microsomal fraction. The present results and those of Bates *et al.*[3] indicate that rat liver mitochondria are capable of independent protein synthesis.

Mitochondria were isolated from rat liver by differential centrifugation of a 1 : 4 sucrose homogenate. Best results were obtained with a mixture containing sucrose (0·3 *M*), versene (0·002 *M*) and nicotinamide (0·03 *M*); this mixture will be referred to as SVN. The fraction collected between 1,000 and 6,000*g* was washed by four successive cycles of re-suspension in and precipitation from SVN. Washed mitochondria in a mixture of sucrose (0·15 *M*), phosphate (0·01 *M*), tris buffer (0·02 *M*), $MgSO_4$ (0·008 *M*) and sufficient KCl to maintain tonicity showed negligible incorporation of labelled amino-acids into mitochondrial protein during aerobic incubations. The mitochondrial protein was obtained by precipitation with trichloroacetic acid and treatment to remove adsorbed amino-acids, ribonucleic acid and lipids. Incorporation was stimulated by the addition of either succinate or α-ketoglutarate,



Ordinates: left, per cent of initial rate of oxidative phosphorylation; right, counts per min.

Fig. 1. Dependence of incorporation of amino-acid into mitochondrial protein upon oxidative phosphorylation. Washed mitochondria from about 3 gm. rat liver were suspended in 5.5 ml. of medium of the following composition: *tris* buffer (0.05 *M*), potassium phosphate (0.01 *M*), potassium succinate (0.01 *M*), magnesium sulphate (0.008 *M*), potassium chloride (0.065 *M*), versene (0.0013 *M*), nicotinamide (0.02 *M*), ^{14}C-*Chlorella* protein hydrolysate (5 μc.), sucrose (0.11 *M*), added as 2.0 ml. boiled cell sap. Incubations were at 30°, in an atmosphere of oxygen. Oxidative phosphorylation was measured essentially as described by Slater (ref. 10), glucose-6-phosphate was estimated by the method of Kornberg and Horecker (ref. 11)

together with cell sap. At an early stage in the investigation it was found that, contrary to the report of Greengard[4], boiled cell sap was just as effective as whole cell sap. Both the rate and the duration of amino-acid incorporation into mitochondrial protein could be increased by adding progressively larger quantities of boiled cell sap. The incorporation reaction was stimulated by incubation in oxygen instead of air and almost completely inhibited by incubation in nitrogen or by the addition of dinitrophenol or cyanide. The behaviour of the incorporation reaction towards inhibitors indicated that incorporation was probably linked to oxidative phosphorylation; amino-acid incorporation and oxidative phosphorylation were accordingly measured in the same mitochondrial preparation. The results (Fig. 1) showed that as the rate of oxidative phosphorylation declined, the rate of incorporation declined in a similar manner.

The duration of oxidative phosphorylation in isolated rat liver mitochondria is notoriously sensitive to conditions of incubation[5]. Calculation of the amount of adenine nucleotide in boiled cell sap indicated that the final concentration of nucleotides in the incubation mixture was below that usually required to maintain mitochondrial structure and oxidative phosphorylation. Accordingly, the boiled cell sap was supplemented with 0.004 *M* adenosine monophosphate and 0.0005 *M* diphosphopyridine nucleotide. Mitochondria incubated under these conditions were able to maintain oxidative phosphorylation and incorporation of labelled amino-acids for 2 hr. at 30°, although the rate of incorporation was falling off after 1 hr. The work of Siekevitz and Potter[5] and of Pressman[6] indicates that the balance of nucleotides and of inorganic phosphate inside the mitochondrial membrane is best maintained when an acceptor for energy-rich phosphate bonds is present in the medium. Thus when the system was further supplemented with hexokinase and glucose, incorporation of amino-acids into mitochondrial protein could be maintained at, or near, a linear rate for 2 hr. at 30°. Incubations have not been carried beyond 2 hr.

Mitochondria are composed of a structurally complex double membrane within which are disposed various soluble but rather firmly bound enzymes. It was found that in the presence of adenosine monophosphate and diphosphopyridine nucleotide, both with and without hexokinase, the insoluble proteins of the mitochondria were effectively labelled either by a mixture of amino-acids labelled with carbon-14 or by a single labelled amino-acid (phenylalanine). Soluble protein was not, however, significantly labelled even after 2 hr. at 30° (soluble protein was released either by the butanol method of Morton[7] or by the extraction of an acetone-dried powder of mitochondria with phosphate buffer). Increase in the amount of boiled cell sap, with maintenance of the adenosine monophosphate and diphosphopyridine nucleotide concentration at the level given above, resulted in a substantial improvement in the efficiency of labelling of the insoluble protein and produced slight activity in the soluble protein. Boiled cell sap contains substantial quantities of amino-acids (80 μgm. amino-nitrogen/ml.) and it was found that these could be replaced by a complete mixture of 20 amino-acids. It was found that, as the concentration of these amino-acids in the incubation medium was progressively increased, the incorporation into insoluble protein rose to a maximum at an amino-acid concentration of 30–40 μ*M*/ml. The incorporation into soluble protein was initially low; but as amino-acid concentration was increased, the radioactivity of the soluble protein continued to rise in an approximately linear manner. Thus the incorporation into soluble protein of the mitochondria progressively becomes a greater proportion of the total incorporation, as amino-acid concentration is increased. The most likely explanation of these results is that there are relatively few sites of protein synthesis in mitochondria (templates?). When these sites become saturated with incoming radioactive amino-acid further increase in amino-acid concentration (of fixed specific radioactivity) will not result in any further increase in radioactivity of insoluble protein. Increased amino-acid concentration will result, however, in a progressively greater tendency for newly synthesized protein to be displaced from the sites of synthesis into the intracisternal spaces so that there will continue to be a progressive increase in the rate of accumulation of radioactivity in soluble protein.

There is no doubt that the amino-acid incorporation reaction measured in these experiments is truly intramitochondrial and is not due to adherent microsomes. First, incorporation is not abolished by thorough washing of the mitochondria as described previously (this washing procedure has been shown to remove at least 95 per cent of microsomes labelled with carbon-14 added to the sedimented mitochondria); secondly, the incorporation reaction does not require fresh cell sap with its supply of soluble ribonucleic acid[8] and 'amino-acid activating' enzymes; thirdly, the incorporation is much more prolonged than that obtained with microsomes *in vitro*; and fourthly, the incorporation is quite unaffected by addition of ribonuclease to the incubation mixture This does not, however, prove that ribonucleic acid plays no part in amino-acid incorporation since we have found that, even after 2 hr at 30° in the presence of ribonuclease, mitochondria retain about 70 per cent of their ribonucleic acid (originally 17 µgm /mgm mitochondrial protein) Indeed, the incorporation reaction in mitochondria may have closely similar characteristics to that occurring in microsomes since we have found that an extract of mitochondria will catalyse an amino-acid-dependent exchange between adenosine triphosphate and radioactive pyrophosphate (Table 1)

Table 1 AMINO-ACID ACTIVATION IN RAT LIVER MITOCHONDRIA

Extract of mitochondria prepared from	c p m per µmole adenosine triphosphate		
	No amino-acids	Plus amino-acids	Increment due to amino-acids
0 6 gm Liver	1,810	2,400	580
1 2 gm Liver	3,060	4,280	1,220

Mitochondria were isolated and washed four times, an acetone powder was prepared and extracted with 0 1 M tris buffer, pH 7 6 This soluble extract was incubated with tris buffer, pH 7 6, 100 µmoles, magnesium chloride, 2 µmoles, adenosine triphosphate, 5 µmoles, a mixture of 12 amino-acids, 2 µmoles of each, ^{32}P-pyrophosphate, about 2 µmoles, 150,000 c p m , vol 1 ml Incubated for 15 min , 37°

Before one can be convinced that the amino-acid incorporation observed in these experiments represents true synthesis of protein, it would be necessary to demonstrate synthesis of a specific protein In this regard the synthesis of cytochrome *c* has already been demonstrated in isolated mitochondria from rat liver[3] and calf heart[9] The presence of numerous enzymes within mitochondria suggests that this *in vitro* system should be a valuable tool in further studies on protein biosynthesis Work has already been initiated along these lines

[1] Palade, G E , and Siekevitz, P , *J Biophys Biochem Cytol* , **2**, 171 (1956)

[2] Littlefield, J W , Keller, E B , Gross, J , and Zamecnik, P C , *J Biol Chem* , **217**, 111 (1955) Simkin, J L , and Work, T S , *Biochem J* , **65**, 307 (1957)

[3] Bates, H M , Craddock, V M , and Simpson, M V , *J Amer Chem Soc* , **80**, 1000 (1958) McLean, J R , Cohn, G L , Brandt, I K , and Simpson, M V , *J Biol Chem* , **233**, 657 (1958)

[4] Greengard, O , *Biochim Biophys Acta*, **32**, 270 (1959)

[5] Siekevitz, P , and Potter, V R , *J Biol Chem* , **215**, 221 (1955) Ernster, L ,and Lindberg, O ,"Ann Rev Physiol ", **20**, 13 (1958)

[6] Pressman, B C , *J Biol Chem* , **232**, 967 (1958)

[7] Morton, R K , "Methods in Enzymology", 1, 40 (1955)

[8] Hoagland, M B , Stephenson, M. L , Scott, J F , Hecht, L I , and Zamecnik, P C , *J Biol Chem* , **231**, 241 (1958)

[9] Bates, H M , and Simpson, M V , *Biochim Biophys Acta*, **32**, 597 (1959)

[10] Slater, E C , *Biochem J* , **53**, 521 (1953)

[11] Kornberg, A , and Horecker, B L , "Methods in Enzymology", 1, 323 (1955)

STRUCTURE OF A MELANOCYTE-STIMULATING HORMONE FROM THE HUMAN PITUITARY GLAND

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A MELANOCYTE-STIMULATING substance from human pituitary glands has recently been isolated in pure form by ion-exchange chromatography[1] It has been shown to be a slightly basic polypeptide which migrates as a single substance when submitted to ionophoresis on paper in pyridine-acetic acid buffers at pH's of 3 6 and 6 5

The amino-acid sequence of the polypeptide hormone has been investigated by methods similar to those described[2,3] for the elucidation of the structure of α-melanocyte-stimulating hormone from pig pituitary glands The particular methods which have been used were to a great extent determined by the limited amount of the substance (4–5 mgm) which was available for study

Specific colour tests[4] carried out on the intact polypeptide showed that it contained tryptophan, tyrosine, histidine and arginine , and when a total acid hydrolysate was submitted to qualitative chromatographic analysis on paper the following amino-acids were shown to be present alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, lysine, methionine, phenylalanine, proline, serine, and tyrosine

A sample of the hormone (2 5 mgm) was allowed to react with chymotrypsin (0 1 mgm) in 0 05 M ammonium bicarbonate (2 ml) at pH 8 0–8 5 and 37° for 10 hr When the product was fractionated by ionophoresis on paper in pyridine-acetic acid (pH 6 5) at 40 volts/cm for 2 hr it was resolved into five peptide fragments

Table 1 AMINO-ACID COMPOSITION AND C-TERMINAL AMINO-ACIDS OF PEPTIDES PRODUCED BY CHYMOTRYPTIC HYDROLYSIS OF HUMAN β-MELANOCYTE-STIMULATING HORMONE

Peptide	Amino-acid composition	C-terminal group
C_1	Ala,Asp,Glu,Gly,Lys,Pro,Tyr	Tyr
C_2	Arg,Asp,Gly,Lys,Pro,Ser,Try	Asp
C_3	Arg,Glu,His,Met,Phe	Phe
C_5	Asp,Gly,Lys,Pro,Ser	Asp
C_6	Arg,Try	Try

The amino-acid compositions of these five peptides (C_1, C_2, C_3, C_5 and C_6) were determined by means of specific colour tests[4], and by paper chromatographic analysis of their total acid hydrolysates , the corresponding C-terminal amino-acids were determined by means of carboxypeptidase[5] The results, summarized in Table 1, showed that the human melanocyte-stimulating hormone was of the 'β-melanocyte-stimulating hormone' type, and that it was closely related in terms of chemical structure to β-melanocyte-stimulating hormone[6,7] from pig pituitary glands Thus, peptides C_2, C_3, C_5 and C_6 were found to have the same electrophoretic mobilities at pH 3 5 and pH 6 5, and the same qualitative amino-acid compositions (with the exception of C_3, which contained arginine instead of lysine), as the corresponding peptide fragments[6] derived from pig β-melanocyte-stimulating hormone by digestion with chymotrypsin Peptide C_1, on the other hand, differed from the corresponding peptide fragment from pig β-melanocyte-stimulating hormone, both in electrophoretic and chromatographic behaviour, and in amino-acid composition, although the C-terminal amino-acid, tyrosine, and four of the other constituent amino-acids—aspartic acid, glutamic acid, glycine and proline—were common to both peptide fragments

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The presence of lysine suggested that C_1 would be susceptible to the action of trypsin It was therefore allowed to react with trypsin for 4 hr at 37° , when the product of reaction was fractionated by ionophoresis at *p*H 6 5 it was resolved into two major (C_1TA_1, C_1TB_1) and two minor (C_1TA_2, C_1TB_2) components Their qualitative amino-acid compositions were determined and are given in Table 2

Table 2 Amino-acid Composition and C-terminal Amino-acids of Peptides produced by Tryptic Hydrolysis of Peptide C_1 (Table 1)

Peptide	Amino-acid composition	C-terminal group
C_1 TA_1	Asp,Glu,Gly,Lys,Pro,Tyr	Tyr
TB_1	Ala,Glu,Lys	Lys
TA_2	Asp,Glu,Gly,Pro,Tyr	Tyr
TB_2	Lys	—

One of the minor peptide components, C_1TA_2, appeared to be identical with the N-terminal peptide, Asp Glu Gly Pro Tyr , in pig β-melanocyte-stimulating hormone[6], as judged by its electrophoretic mobility at *p*H 6 5, R_F in butanol-acetic acid-water (4 1 5), amino-acid composition, and C-terminal group The two major peptide components, C_1TA_1 and C_1TB_1, were both found to contain lysine , and the fact that a significant amount of free lysine (C_1TB_2) was also formed in the tryptic reaction suggested that the parent molecule, C_1, contained a Lys Lys bond, and that it was the N-terminal peptide (Ala,.Glu) Lys Lys (Asp Glu Gly Pro) Tyr in the human β-melanocyte-stimulating hormone molecule

After their homogeneity had been established both by electrophoretic and chromatographic analysis, peptides TA_1, TA_2, TB_1 and C_5 were submitted to partial acid hydrolysis (12 *N* hydrochloric acid, for 3–6 days at 37°) , peptide C_3 was hydrolysed with subtilisin[8] (12 hr at 37°) The respective products of reaction were fractionated by ionophoresis on paper and were characterized by the procedures which have been described previously[3,6] The results are summarized in Table 3

Peptide C_2 was shown to give additional amounts of C_5 and C_6 when it was redigested with chymotrypsin, showing that C_5 and C_6 formed contiguous sequences in the molecule By means of carboxypeptidase, C_6 was shown to be a dipeptide containing arginine and tryptophan , in a similar manner aspartic acid was shown to be the C-terminal amino-acid in both C_2 and C_5, showing that these two peptides formed the C-terminal sequence, Arg Try (Gly,Ser,Pro, Lys) Asp, in human β-melanocyte-stimulating hormone (cf ref 6)

Although it was not found possible to undertake quantitative amino-acid and end-group analyses on the parent molecule, the results which have been obtained with peptide fragments derived from it by hydrolysis with chymotrypsin and trypsin nevertheless appear to be sufficient to establish that human β-melanocyte-stimulating hormone contains twenty-two amino-acid residues, and that they occur in the following sequence

Table 3 Peptides Identified in Partial Acid* (12 *N* Hydrochloric Acid, 37°) and Subtilisin† Hydrolysates

Peptide	Products of partial hydrolysis
*C_1TB_1	Ala Glu, Glu Lys
*C_1TA_1	Lys Asp, Lys Asp Glu, Glu Gly, Gly Pro Tyr
*C_5	Ser Pro, Ser Pro Pro, Ser Pro Pro Lys, Pro Pro Lys, Pro Lys, Lys Asp
†C_3	Arg Met, Arg Met Glu, Glu His, Glu His Phe

1 2 3 4 5 6 7 8 9 10 11
H— Ala Glu Lys Lys Asp Glu Gly Pro Tyr Arg Met
12 13 14 15 16 17 18 19 20 21 22
Glu His Phe Arg Try Gly Ser Pro Pro Lys Asp — OH

This appears to be the first of the polypeptide hormones from the human pituitary to be isolated in pure form and to be characterized in terms of its complete chemical structure The amino-acid sequences of human, pig[6,7] and ox[9] β-melanocyte-stimulating hormones and pig α-melanocyte-stimulating hormone[2,3] are compared in Fig 1

Although human β-melanocyte-stimulating hormone manifests a structural 'species' difference of the 'classical' type, namely, the replacement of a lysine residue (position 6 in pig and ox β-melanocyte-stimulating hormone) by arginine (position 10 in human β-melanocyte-stimulating hormone) in structurally related positions, the presence of the additional N-terminal tetrapeptide, Ala Glu Lys Lys, represents a hitherto unprecedented structural species variation among naturally occurring biologically active polypeptide and protein molecules of relatively low molecular weight (for example, vasopressins[10,11], corticotropins[12], insulins[13] and hypertensins[14,15])

Ox β-melanocyte-stimulating hormone[9] is found to differ from pig β-melanocyte-stimulating hormone only in position 2 (Fig 1), where the glutamic acid residue in the pig hormone is replaced by a serine residue in the ox hormone It is perhaps significant that the replacement of one amino-acid by another which is structurally unrelated to it occurs in a part of the molecule which does not appear to be specifically essential for its biological activity[3] (cf corticotropins[12]) Presumably genetical alterations which produce structural modifications of this type in essential parts of the molecule would result in the formation of molecules in which biological specificity was either modified or destroyed Consequently the fact that a lysine residue in the pig and ox hormones is replaced by the structurally related amino-acid, arginine, in the human hormone, and that the structural features common to all known β-melanocyte-stimulating hormones and corticotropins[12,16]

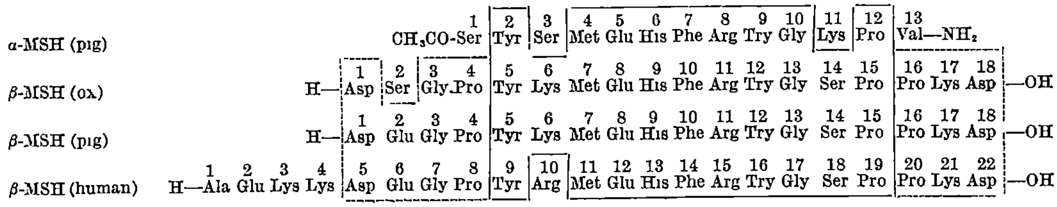
α-MSH (pig)
1 CH₃CO-Ser 2 Tyr 3 Ser 4 Met 5 Glu 6 His 7 Phe 8 Arg 9 Try 10 Gly 11 Lys 12 Pro 13 Val—NH₂
β-MSH (ox)
H— 1 Asp 2 Ser 3 Gly 4 Pro 5 Tyr 6 Lys 7 Met 8 Glu 9 His 10 Phe 11 Arg 12 Try 13 Gly 14 Ser 15 Pro 16 Pro 17 Lys 18 Asp —OH
β-MSH (pig)
H— 1 Asp 2 Glu 3 Gly 4 Pro 5 Tyr 6 Lys 7 Met 8 Glu 9 His 10 Phe 11 Arg 12 Try 13 Gly 14 Ser 15 Pro 16 Pro 17 Lys 18 Asp —OH
β-MSH (human)
H— 1 Ala 2 Glu 3 Lys 4 Lys 5 Asp 6 Glu 7 Gly 8 Pro 9 Tyr 10 Arg 11 Met 12 Glu 13 His 14 Phe 15 Arg 16 Try 17 Gly 18 Ser 19 Pro 20 Pro 21 Lys 22 Asp —OH

Fig 1 Amino-acid sequences of melanocyte-stimulating hormones from pig, ox and human pituitary glands MSH, melanocyte-stimulating hormone

remain intact, suggests that the amino-acids which occupy these key positions in β-melanocyte-stimulating hormone are directly associated with its biological activity in the *in vivo* environment in which it has been designed to function as a hormone

In α-melanocyte-stimulating hormone, on the other hand, there is an *interchange* of lysine and serine residues between positions 3 and 11 (Fig 1), which correspond to positions 6 and 14 in pig and ox β-melanocyte-stimulating hormones, and to positions 10 and 18 in human β-melanocyte-stimulating hormone This would suggest that factors other than the linear arrangement of amino-acid residues must be taken into consideration in relating structure to biological function in the living cell even in comparatively small peptide molecules which do not appear to possess any ordered secondary or tertiary structure in aqueous solution

I am indebted to Dr H B F Dixon for his generous gift of the sample of pure human melanocyte-stimulating hormone Most of the experimental work was carried out in the Division of Biochemistry of the Massachusetts Institute of Technology, and I am indebted to Dr Vernon Ingram for his kindness in placing the facilities of his laboratory at my disposal. [May 6

[1] Dixon, H B F, *Biochim Biophys Acta* (in the press)

[2] Harris, J I, and Lerner, A B, *Nature*, **179**, 1346 (1957)

[3] Harris, J I, *Biochem J*, **71**, 451 (1959)

[4] Block, R J, Durrum, E L, and Zweig, G, "A Manual of Paper Chromatography and Paper Electrophoresis", 87 (Academic Press, Inc, New York, 1955)

[5] Fraenkel-Conrat, H, Harris, J I, and Levy, A L, in "Methods of Biochemical Analysis", 2, 359, ed by Glick, D (Interscience Publishers, Inc, New York, 1955)

[6] Harris, J I, and Roos, P, *Nature*, **178**, 90 (1956), *Biochem J*, **71**, 434 (1959)

[7] Geschwind, I I, Li, C H, and Barnafi, L, *J Amer Chem Soc*, **78**, 4494 (1956), **79**, 620 (1957)

[8] Guntelberg, A V, and Ottesen, M, *C R Lab Carlsberg* (Ser chim), **29**, 36 (1954)

[9] Geschwind, I I, Li, C H, and Barnafi, L, *J Amer Chem Soc* **79**, 1003 (1957)

[10] Vigneaud, V du, Lawler, H C, and Popenoe, E A, *J Amer Chem Soc*, **75**, 4880 (1953) Acher, R, and Chauvet, J, *Biochim Biophys Acta*, **12**, 487 (1953) Acher, R, Chauvet, J, and Lenci, M T, *Biochim Biophys Acta*, **31**, 545 (1959)

[11] Popenoe, E A, Lawler, H C, and du Vigneaud, V, *J Amer Chem Soc*, **74**, 3713 (1952)

[12] Li, C H, in "Symposium on Protein Structure", 302, ed by Neuberger, A (Methuen and Co, Ltd, London, 1958)

[13] Harris, J I, Sanger, F, and Naughton, M A, *Arch Biochem Biophys*, **65**, 427 (1956)

[14] Elliott, D F, and Peart, W S, *Nature*, **177**, 527 (1956), *Biochem J*, **65**, 246 (1957)

[15] Skeggs, L T, Lentz, K E, Kahn, J R, Shumerway, N P, and Woods, K R, *J Exp Med*, **104**, 193 (1956)

[16] Harris, J I, in "Symposium on Protein Structure", 333, ed by Neuberger, A (Methuen and Co, Ltd, London, 1958)

GROWTH PATTERNS IN *NEUROSPORA*

A Biological Clock in *Neurospora*

MANY fungi produce alternating zones of different growth type in response to diurnal light-cycles and temperature-cycles, and in some cases the zonation will continue to be produced for a time in continuous darkness and at a constant temperature In 1953 Brandt[1] reported observation of zonation in the growth and conidia formation of *Neurospora crassa* mycelia in standard glass race-tubes maintained in constant darkness, humidity and temperature Inspection of Brandt's photographs suggested to us that the zones were formed with a frequency of approximately one a day, and we have tested the implication that there does occur in *Neurospora* a typical biological daily clock—that is, a rhythmic system with an innate circadian ('about a day') period which is relatively independent of the temperature (We are here adopting the suggestion (personal communication) of Prof F Halberg that the word 'circadian' obviates all the long-standing confusion inherent in the words diurnal, daily, 24-hr, as adjectives to describe the rhythms with which we are concerned)

Brandt reported that he obtained zonation in only one (No 21863, prolineless) strain of several that he examined, and that the zonation occurred on only one of the supplemented media ('Gray's') that would support growth of this strain Zonation occurred at constant temperature either in a 24-hr light–dark cycle, or in continuous darkness after a brief period of initial growth in white light Zonation does not develop if the mycelium is maintained in continuous white light, but we have found that it can develop in continuous red (carbon) light

In the experiments reported here the same strain and media as those used by Brandt were also used Freshly inoculated race-tubes were placed in a temperature-controlled cabinet containing a 14-watt cool-white fluorescent lamp About 40 hr later, when the mycelium was growing well, the white light was discontinued and a red lamp was turned on At this time and at 24 hr intervals thereafter the advance of the mycelial front was observed (in the red light) and marked on the race-tube When the growth had reached the end of the agar, the tube was removed from the growth cabinet and a densimeter device was used to measure relative density of the mycelium along its entire length The observed phenomenon consists of alternating zones of sparse and dense mycelium Preliminary experiments failed to reveal any significant difference in the linear growth increments in the 4-hr intervals throughout any 24-hr interval The distribution of mycelial density has accordingly been converted from its observed spatial scale to a temporal scale Regions of dense growth show up as minima on the densimeter graphs

Fig 1 illustrates the results so obtained from two typical race-tubes, one maintained at 31° C and the other at 24° C Table 1 summarizes more extensive data on the time-interval between successive minima on the densimeter graphs This interval, which is the period of the rhythm, is about 22 hr and is the same at the two temperatures

The zonation of *N crassa* thus is regulated by a rhythmic phenomenon which manifests the essential features of a biological clock[2] The rhythm has an innate free-running period which is close to 24 hr relatively independent of the temperature The rhythm can be entrained by a 24-hr light-cycle In addition to possessing these functional prerequisites of a good chronometer, the rhythm also possesses other features of typical circadian systems (1) The phase of the rhythm can be established by a single transition from light to dark, (2) as with many other plant rhythms, the manifestation of the rhythm is

Table 1 TABULATION OF TIME-INTERVALS BETWEEN ZONES (MEASURED AS TIME BETWEEN SUCCESSIVE MINIMA ON DENSIMETER GRAPHS) AT THE TWO TEMPERATURES STUDIED

No of intervals at 24° C	Length of interval (hr)	No of intervals at 31° C
	18	2
2	17	
2	20	2
	20 5	2
4	21	3
	21 5	4
11	22	6
	22 5	1
7	23	1
	23 5	1
2	24	2
	25	
1	26	
	26 5	1
22 03	Mean interval	21 66
1 48	Std dev	1 80

destroyed by continuous white light We have not yet studied entrainment by temperature-cycles, or the transient[3] pattern following single light signals

The *Neurospora* system appears potentially valuable for an attack on the basic problem of the nature of the oscillations that constitute the circadian clock We do not interpret the presence or absence of zonation as a reflexion of the presence or absence of the clock, but rather as a coupling or uncoupling from the clock of the particular processes leading to zonation Thus, it may be necessary to find some other manifestation of the basic rhythm which is present even when there is no zonation before one can make all the intriguing analyses that seem potentially possible However, the possibility of genetic analysis, the feasibility of heterokaryon formation, and the fact that *Neurospora* can be grown on fully defined media are features which make the system uniquely useful For example, the pattern of zonation in a heterokaryon between two strains with a previously established 12-hr phase difference might resolve the question Is the clock oscillation a nuclear or a cytoplasmic feature ?

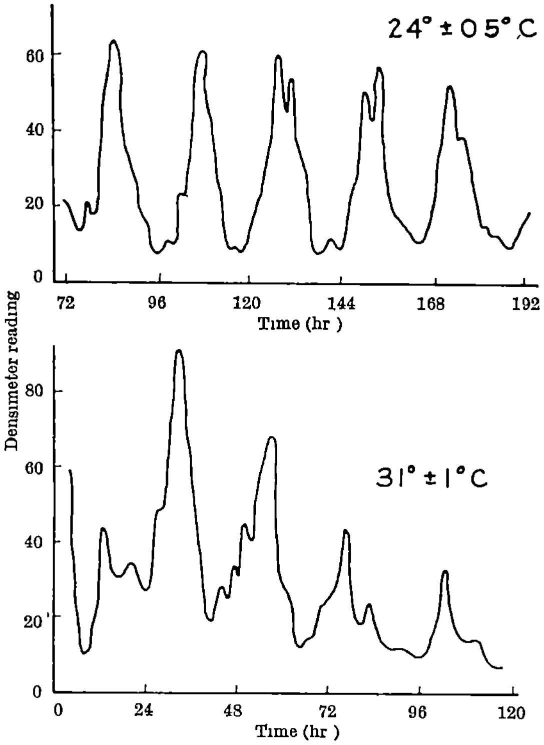

Fig 1 Zonation in *Neurospora* Zonation of the growth in a race-tube of a prolineless strain of *Neurospora* has been measured using a densimeter to record the relative density of mycelial growth The time-scale shown represents hours elapsed after transfer of the race-tubes from white light to dim red light as described in the text

This work was supported by a grant from the National Science Foundation and by funds from the Eugene Higgins Trust allocated to Princeton University We are indebted to Prof N Horowitz, California Institute of Technology, for kindly providing us with Strain No 21863

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[1] Brandt, W H , *Mycologia*, 45, 194 (1953)

[2] Pittendrigh, C S , and Bruce, V G , in "Rhythmic and Synthetic Processes in Growth", ed D Rudnick, 75 (Princeton University Press, 1957)

[3] Pittendrigh, C S , Bruce, V G , and Kaus, P , *Proc U S Nat Acad Sci* , 44, 965 (1958)

Genetic Control of a Cyclic Growth Pattern in *Neurospora*

A STRAIN of *Neurospora* has been described which displays a daily cycle of growth morphology[1], and it has been demonstrated that this growth pattern reveals the presence in the organism of a temperature-independent biological clock[2] The cyclic growth pattern consists of alternating regions of dense and sparse mycelium Each dense region has a conspicuous tuft, or patch, of aerial growth on which orange macroconidia are produced The pattern was demonstrated by strain 21863*a*, a proline-requiring mutant, when grown in race-tubes of Gray's medium[1] Other strains grown in the same conditions produce a uniformly dense mycelium, and conidia formation occurs much later than in the tufts of 21863 This report concerns a study of the genetic control of this growth pattern The cyclic growth condition will be termed 'patch', and the symbol will be *pat* ('tuft' has already been used for another phenotypic character)

Strain 21863*a* was crossed to wild-type 74*A* Asci were dissected into ordered spore pairs Eight complete asci (all four spore pairs growing) were classified for mating type, proline requirement, and patch (Table 1) The cyclic growth pattern segregated 2 2 in every ascus, as did mating type and proline requirement Patch and proline requirement are controlled by separate genes which are not closely linked On the other hand, patch showed close linkage to mating type, in these eight asci there was no recombination between them

The mating type locus is in the left arm of linkage group I Failure to metabolize nitrate is determined by a gene (*n-nit*) in the right arm[3] The cross *pat a* × *n-nit A* was dissected, and thirteen complete asci were obtained Their classification is shown in Table 2 The results indicate the patch locus is in the left arm of linkage group I, proximal to mating type

Classification of the progeny of these crosses for patch was made in race-tubes of Gray's medium at 25° C , the tubes were in constant light for 24 hr , then transferred to constant dark for 2–3 days before scoring Tests in minimal medium[4] (supplemented

Table 1 74 *A* (WILD-TYPE) × 21863*a* (*prol pat*)

No of asci	Genotypes of ordered spore pairs
4	*prol*+ *pat*+ *A* *prol*+ *pat*+ *A* *prol* *pat* *a* *prol* *pat* *a*
2	*prol*+ *pat* *a* *prol*+ *pat* *a* *prol* *pat*+ *A* *prol* *pat*+ *A*
2	*prol*+ *pat*+ *A* *prol* *pat*+ *A* *prol*+ *pat* *a* *prol* *pat* *a*

Totals

No of spore pairs	Genotype	Growth on Gray's medium
10	*prol*+ *pat*+*A*	no lag
10	*prol* *pat* *a*	no lag
6	*prol*+ *pat* *a*	no lag
6	*prol* *pat*+ *A*	3 day lag

Note Different patterns of second division segregation have been grouped together for brevity

with proline) and in complete medium[5] were carried out in race-tubes in the same light and temperature conditions, but not all the *pat* segregants gave clear-cut cyclic growth patterns

Normally, growth began quickly on Gray's medium and extended 1–4 cm down the length of the race-tube after 24 hr However, six of the cultures had a lag period of about three days before any growth appeared These were the six proline-requiring *pat*+ segregants of the first cross (Table 1) There is thus a physiological interaction which might be described as partial suppression of *prol* by *pat* (though it could also be suppression by mating type gene *a*) Whether this interaction is related to the function of the biological clock is unknown (The lag period occurred only on Gray's medium , none of the cultures lagged on minimal medium plus proline or on complete medium)

Table 2 *pat a* × *n-nit A*

No of asci	Genotypes of ordered spore pairs	Simplest cross-over events required assuming following order of loci I II III *A*, *a* *pat* centromere *n-nit*
4	*a pat* *n-nit*+ *a pat* *n-nit*+ *A pat*+ *n-nit* *A pat*+ *n-nit*	no crossing over
4	*a pat* *n-nit*+ *a pat* *n-nit* *A pat*+ *n-nit*+ *A pat*+ *n-nit*	single crossover in III
2	*a pat* *n-nit*+ *A pat*+ *n-nit*+ *a pat* *n-nit* *A pat*+ *n-nit*	single crossover in II
1	*a pat* *n-nit*+ *A pat* *n-nit*+ *a pat*+ *n-nit* *A pat*+ *n-nit*	single crossover in I
1	*a pat* *n-nit*+ *A pat*+ *n-nit* *a pat* *n-nit*+ *A pat*+ *n-nit*	2-strand double in II, III
1	*a pat* *n-nit*+ *A pat*+ *n-nit* *a pat* *n-nit* *A pat*+ *n-nit*+	3-strand double in II, III

Note Different patterns of second division segregation have been grouped together for brevity

The tests for proline requirement were made on plates containing the sugar sorbose , this causes growth to remain restricted to the spot of the inoculum, rather than spreading over the plate The use of sorbose medium allows as many as twenty-five growth tests to be performed on a single plate It was observed that some of the test colonies did not remain confined on the sorbose plates, but were expanding radially 5–10 mm per day The 'sorbose-escape' condition turned out to be characteristic of the patch segregants This was a consistent correlation , all 42 *pat* progeny from the two crosses escaped on sorbose, while all 42 *pat*+ progeny remained confined on sorbose There was no evidence of any cyclic pattern in the sorbose-escape colonies Sorbose-escape was achieved even on plates held in constant light, a condition in which the cyclic growth pattern is not observed on Gray's medium

The sorbose-escape classification demonstrates that the presence of the patch gene can be detected in a situation in which it is not visibly related to a biological clock It is possible that the patch gene is not directly involved in the function of the biological clock, but, rather, effects a growth habit which reveals an underlying clock However, this could only be determined conclusively by a demonstration of clock activity in a *pat*+ strain

This work was supported by a grant from the National Science Foundation I am grateful to Dr C S Pittendrigh and Dr V G Bruce, of Princeton University, for providing the strain 21863*a*

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[1] Brandt, W H , *Mycologia*, **45**, 194 (1953)

[2] Pittendrigh, C S , Bruce, V G , Rosensweig, N S , and Rubin, M L (previous communication)

[3] Barratt, R W , Newmeyer, D , Perkins, D D , and Garnjobst, L , "Advances in Genetics", VI, 1 (1954)

[4] Vogel, H J , *Microbial Genetics Bull* , **13**, 42 (1956)

[5] Horowitz, N H , *J Biol Chem* , **171**, 255 (1947)

PROTHORACIC GLAND STIMULATION BY JUVENILE HORMONE EXTRACTS OF INSECTS

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THE juvenile hormone was first recognized as the agent which prevents maturation of young insects[1] A second role for this hormone, discovered shortly thereafter, was in egg development where, in many insects, it is necessary for yolk deposition[2] The present article describes what appears to be a third role for the juvenile hormone, namely, stimulation of the prothoracic glands This tropic action has hitherto been assigned either to a hormone secreted by the insect's brain[3] or occasionally to low temperature[4] Experiments were conducted on pupæ of a variety of giant silk moths of the family Saturniidae *Hyalophora cecropia*, *Samia cynthia*, *Antherea polyphemus* and *Callosamia promethea* Pupæ in two physiological states were employed as test objects (*a*) diapausing pupæ which ordinarily remain for months in the pupal stage without developing, (*b*) pupæ which were stored at 5–8° C for 5 months or more to activate their brains[3] Such 'well-chilled' pupæ ordinarily initiate development within two weeks of being placed at 25° C and emerge as adults $2\frac{1}{2}$–3 weeks later

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In the first series of experiments, ether extracts were made of abdomens of male *H cecropia* moths following Williams's procedure[5] These ether extracts contain large amounts of juvenile hormone When the extracts were injected into diapausing *S cynthia* pupæ these moulted into second pupæ For our present purposes the fact that the second moult was pupal is unimportant since a moult of a pupa in the presence of juvenile hormone will almost invariably be pupal However, it is of interest that moulting occurred, for in our experience not one of thousands of diapausing *S cynthia* pupæ has ever initiated adult development without prior chilling Nevertheless, injection of 50 mgm or more of ether extract invariably caused these diapausing pupæ to moult precociously into second pupæ or pupal-adult intermediates (Table 1*A*) Pupæ that received less than 50 mgm failed to initiate adult development Similar results were obtained with both newly moulted and older diapausing pupæ of *H cecropia* and *A polyphemus* (Table 1*B*) In all cases, the ether extracts terminated pupal diapause

Table 1

(*A*) Moulting of unchilled seven-month-old diapausing *S cynthia* pupæ after injections of ether extracts*

Pupal weight (gm)	Mgm extract injected	Days to moult	Effect
1 60	50	27	Adult-like intermediate
1 56	100	13	Second pupa
1 83	100	17	Second pupa
1 65	150	13	Second pupa
1 80	150	23	Pupa-like intermediate

* Uninjected controls did not initiate development after 6 months

(*B*) Moulting of unchilled one-month-old diapausing pupæ of *H cecropia* and newly moulted diapausing pupæ of *H cecropia* and *A polyphemus* after injections of ether extracts

Pupal weight (gm)	Mgm extract injected	Days to moult	Effect
	H cecropia (one month)*		
4 65	100	—	No development after 6 months
5 30	200	23	Adult-like intermediate
5 25	250	13	Pupa-like intermediate
5 45	400	17	Pupa-like intermediate
5 40	400	—	No development after 6 months
5 46	450	23	Pupa-like intermediate
4 80	600	23	Pupa-like intermediate
4 75	600	23	Pupa-like intermediate

* Uninjected controls did not initiate development after 6 months

Hours after moulting	Mgm extract injected	Days to moult	Effect
	H cecropia (newly moulted)*		
4	100	—	No development after 6 months
12	300	19	Adult-like intermediate
36	100	31	Adult with few pupal characters
	A polyphemus (newly moulted)*		
Prepupa	200	—	No development after 3 months
1	200	55	Adult-like intermediate
6	200	23	Adult-like intermediate
10	150	19	Pupa-like intermediate
12	250	33	Pupa-like intermediate

* Uninjected controls did not initiate development after 3 months

In addition, when extracts were injected into 'well-chilled' pupæ they caused precocious moulting Thus, results of more than 800 injections into well-chilled pupæ of *S cynthia*, *C promethea*, *H cecropia* and *A polyphemus* disclosed that pupæ receiving more than 50 mgm of ether extract invariably moulted into second pupæ within 10–13 days These several results suggest that the juvenile hormone or some other constituent of the ether extracts stimulates moulting

To decide whether the ether extracts provoke moulting by stimulating the pupal brain or by directly stimulating the prothoracic glands, the following experiments were performed A series of diapausing *H cecropia* pupæ had their brains removed This placed the pupæ in permanent diapause and such brainless pupæ never spontaneously initiate adult development However, when three such brainless pupæ were injected with 200, 400 and 600 mgm of ether extract, the two which received the largest injections moulted into second pupæ while the third remained in diapause (Table 2) Similar results were obtained with brainless *S cynthia* pupæ (Table 2) From these experiments, it appears that large amounts of ether extract stimulate the prothoracic glands and so terminate pupal diapause

Table 2

(*A*) Moulting of brainless diapausing pupæ of *H cecropia* and *S cynthia* after injections of ether extracts

Pupal weight (gm)	Mgm extract injected	Days to moult	Effect
		H cecropia	
6 73	200	—	Never initiated development
5 53	400	41	Second pupa
6 10	600	32	Second pupa
		S cynthia	
1 90	100	13	Second pupa
3 21	250	15	Second pupa

An alternative explanation is that the ether extract contained some prothoracic gland hormone, ecdyson, and this reacted directly with the pupal tissues to initiate development This possibility was tested by injecting a large series of isolated pupal abdomens of *S cynthia* and *A polyphemus* with 80–300 mgm of ether extract None of these preparations ever initiated development, although many survived as long as four months. Moreover, repeated efforts to extract ecdyson from the ether extracts have failed These results seem to rule out the prothoracic gland hormone as the effective moult-promoting agent in the ether extracts Hence, it seems safe to conclude that something in the ether extracts stimulates the insect's prothoracic glands

To determine whether the factor which stimulated the prothoracic glands was the juvenile hormone itself, or some other substance, extracts in which juvenile hormone was concentrated 100–500-fold by various chemical procedures[6] were injected into chilled pupæ, diapausing pupæ and brainless pupæ As Table 3*A* reveals, the concentrated juvenile hormone preparations had potent prothoracic gland-stimulating activity Indeed, the prothoracic gland-stimulating factor was concentrated to about the same degree as the juvenile hormone by the chemical procedures we employed Moreover, when brainless diapausing pupæ were injected with huge amounts of ether extract from which juvenile hormone had been removed by countercurrent distribution, they failed to respond (Table 3*B*) In short, procedures which concentrate the juvenile hormone, concentrate the

Table 3

(*A*) Precocious moulting of well-chilled *A polyphemus* pupæ after injection of purified juvenile hormone extracts

Pupal weight (gm)	Mgm extract injected	Days to moult	Effect
		Extract *A*	
4 19	2 3	13	Second pupa
5 26	5	12	Second pupa
5 15	8	10	Second pupa
4 90	15	13	Second pupa
		Extract *B*	
4 15	0 05	13	Second pupa
5 05	0 10	13	Second pupa
4 91	0 10	11	Second pupa

(*B*) Effect of juvenile hormone-free extracts on brainless diapausing *S cynthia* pupæ

Pupal weight (gm)	Mgm extract injected	Days to moult	Effect
3 20	180	—	Never initiated development
2 13	270	—	Never initiated development
2 19	300	—	Never initiated development
3 30	400	—	Never initiated development
2 80	450	—	Never initiated development

prothoracic gland-stimulating factor and procedures which remove juvenile hormone from extracts, also remove the prothoracic gland-stimulating factor These results indicate that the juvenile hormone or a molecule with similar chemical properties, perhaps brain hormone, is the effective agent in the extracts that triggers off the prothoracic glands Hence, we may conclude that either the juvenile hormone stimulates the prothoracic glands or the extract contains brain hormone in addition to juvenile hormone.

A final decision between these alternatives awaits tests with pure juvenile hormone preparations, but some insight is provided by two recent reports which were published when the present experiments were completed Williams[7] has announced that implantation of active corpora allata terminates diapause in brainless diapausing *H cecropia* pupæ This important result is consistent with the view that the juvenile hormone itself is the effective agent in our extracts that activates the prothoracic glands This prospect is made more attractive by the recent report of Kobayashi and Kerimura[8], which indicates that brain hormone extracted from the commercial silkworm has similar solubility properties to juvenile hormone Thus it seems possible that brain hormone is similar chemically to juvenile hormone, and it is perhaps not too surprising that both hormones can activate the prothoracic glands Whether or not the juvenile hormone actually functions in any immature insect to stimulate the prothoracic glands and cause moulting remains to be seen

We wish to express our thanks to Dr Berta Scharrer for her critical evaluation of this manuscript

Note added in proof Ichikawa, M , and Nishiitsutsuji-Uwo, J (*Biol Bull* , **116**, 88; 1959), have shown that the corpora allata of *Philosamia cynthia ricini* can induce moulting in brainless pupæ Their results indicate that, in addition to eliciting juvenile hormone, the corpora allata store neurosecretory material transported from the brain via the nervi corporis allati They conclude that implants of larval and adult corpora allata furnish two hormones controlling post-embryonic development, namely, juvenile hormone and a moult-inducing hormone derived from the protocerebrum (brain hormone) These results suggest that extracts of male *H cecropia* moths may contain brain hormone in addition to juvenile hormone

[1] Wigglesworth, V B , *Quart J Micro Sci* , **77**, 191 (1934)

[2] Wigglesworth, V B , *Quart J Micro Sci* , **79**, 91 (1936)

[3] Williams, C M , *Biol Bull* , **90**, 324 (1946)

[4] Ozeki, K , Sci Papers Coll Gen Education, Univ Tokyo, **4** (1954)

[5] Williams, C M , *Nature*, **178**, 212 (1956)

[6] Schneiderman, H A , and Gilbert, L I , *Anat Rec* , **128**, 618 (1957)

[7] Williams, C M , *Biol Bull* , **116**, 323 (1959)

[8] Kobayashi, M , and Kerimura, J , *Nature*, **181**, 1217 (1958)

EVOKED POTENTIALS IN VISUAL CORTEX OF THE UNANÆSTHETIZED CAT

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RECENT work has indicated that when an animal 'attends' to a non-visual stimulus, photically evoked potentials in the visual pathway of the unanæsthetized cat are reduced[1] It was concluded from these and other studies[2] that this depression of evoked responses implies a reduction of the sensory inflow which, if it occurs " in all other sensory paths except the ones concerned with the object of attention, such an inhibitory mechanism might lead to the favouring of the attended object by the selective exclusion of incoming signals"[2] It is not clear how, in the above experiments, 'attentive' behaviour was assessed, though in the studies of the visual system the cat's 'attention' was attracted, among other things, by a call or by fish odour delivered to the cage When a cat is called, it may look toward the source of the voice when a fish odour is blown into the cage the cat usually responds by sniffing and looking toward the source of the odour If the animal failed to make these responses, it is not apparent how 'attentive' behaviour was otherwise assessed Hence it is difficult to escape the conclusion that presentation of a non-visual stimulus may have resulted in the cat searching the visual field The above experiments do not therefore exclude the possibility that the evoked responses were reduced in the modality actually being used for examining the sensory field

The following experiments were undertaken to determine the changes in cortical evoked response to light flash in the unanæsthetized cat, when its behaviour was directed toward an object in the visual field (mouse) and to a non-visual stimulus (conditioned tone) respectively Six cats were used A monopolar electrode of approximately 1 mm tip diameter was placed on the visual cortex using as indifferent electrode a screw driven into the frontal bone Several days after operation the animal was put in a box illuminated by a 6-volt battery bulb

Evoked responses to flash were displayed on an oscilloscope and filmed while the cat was resting facing the stroboscope. The flash, delivered once in approximately 2 sec., was of 1-m. sec. duration with an intensity of approximately 1 lambert. A mouse was introduced between stroboscope and cat, separated from the latter by a transparent plastic sheet. During the first few presentations of the mouse, the cat usually was intensely excited; but later it sat still, intently watching the mouse with little or no pilo-erection, or unsheathing of the claws. At this time 20 evoked responses to flash were recorded. Ten of these experimental responses were selected at random from the 20, together with 10 control evoked responses from the resting animal, recorded immediately before introduction of the mouse. The mean of each of these sets of results was calculated. These means for each animal were tabulated and the significance of any differences between experimental and control conditions obtained by applying a paired *t* test. It was found that when the cat was watching the mouse the electrocorticograph was flattened. The surface positive component of the primary wave of the evoked potential was decreased by 27 per cent ($P < 0.001$), and its duration reduced by 20 per cent ($P < 0.01$). The amplitude of the surface negative component was decreased by 21 per cent ($P < 0.02$). The excursion of the second wave of the response was reduced by 19 per cent ($P < 0.02$) and waves of the later components by 51 per cent ($P < 0.001$).

In order to orientate the cat's behaviour to a non-visual modality, the animal was conditioned to receive a slight shock to the fore-limbs after several tones, each delivered in the interval between consecutive flashes. The number of tones delivered prior to the shock was varied between 2 and 10 in any trial. After the first few trials, shocks were only occasionally applied. During the early stages of conditioning, at the onset of the tones, the cat looked intently around the box. At this time the electrocorticograph was reduced in amplitude. The surface positive component of the primary wave was reduced by 21 per cent ($P < 0.02$) and its duration by 19 per cent ($P < 0.02$); the amplitude of the second wave of the response was attenuated by 34 per cent ($P < 0.01$) and the later oscillations by 40 per cent ($P < 0.02$).

At a later stage of conditioning, the cat did not look around the box during the tones, but remained still except for some slight shifting of the fore-limbs, twitching of the facial muscles and flicking of the ears. Occasionally at this stage the cat got up during the tones and settled in another part of the cage. Measurement of records taken when the animal showed minimal movement and when its response to the acoustic stimulus was accompanied by little or no 'visual searching' component showed that the amplitude of the electrocorticograph was diminished. The amplitude and duration of the evoked responses were not, however, significantly different from those recorded under control conditions.

From the above results it appears that photically evoked responses in the visual cortex are not attenuated when a cat's behaviour is orientated to an acoustic stimulus, so long as there is no visual searching component in the animal's behavioural response. On the other hand, when the animal's behaviour is directed to a stimulus in the visual field, or shows some visual searching component in its response to a non-visual stimulus, evoked potentials are reduced in amplitude. It might be argued that when the cat was looking at a mouse the information contained in the flash was irrelevant and so attenuated. However, when the animal's behaviour was directed to the acoustic stimulus, in the absence of visual searching activity, the information from the flash was likewise irrelevant. The evoked potentials in these two situations should therefore have been treated similarly. They were not.

Reduction in amplitude of an evoked response to a given photic input may be brought about in one or more ways (for example, inhibition, reduction of facilitation, occlusion). Whatever the mechanism, one of the effects of such activity may be, in some circumstances, to increase sensory contrast and so improve the sharpness of input boundaries. Absence of such input attenuating activity in the visual system, as when behaviour is directed to an acoustic stimulus, could give a greater absolute sensitivity in the visual pathway. The animal would thus monitor its environment more sensitively so providing central mechanisms with a maximum of information on which to act.

One of us (G. H.) wishes to thank the Wellcome Trust and the National Research Council of Canada for grants toward the cost of travel expenses. Thanks are also due to Prof. H. Jasper for his interest in this work.

[1] Hernández-Peón, R., Guzmán-Flores, C., Alcarez, M., and Fernández-Guardiola, A., *Acta Neurol. Latinoamer.*, 3, 1 (1957).

[2] Hernández-Peón, R., Scherrer, H., and Jouvet, M., *Science*, 123, 331 (1956).

INFLUENCE OF UNBALANCED GROWTH ON SUBSEQUENT X-RAY-INDUCED INHIBITION OF DEOXYRIBONUCLEIC ACID SYNTHESIS IN *ESCHERICHIA COLI* 15_{T-}

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IN an earlier report[1] it was demonstrated that the number of survivors among X-irradiated *Escherichia coli* strains *B/r* and 15_{T-} (thymine-less) was increased when log-phase cells were incubated in the presence of chloramphenicol prior to X-ray exposure. In the case of *E. coli* 15_{T-} deoxyribonucleic acid synthesis was necessary for the development of radioresistant cells, since when deoxyribonucleic acid synthesis was prevented by the removal of thymine from the pre-irradiation incubation medium, radioresistance was not enhanced by chloramphenicol. One interpretation of these results was that 'surplus' deoxyribonucleic acid formed in the presence of chloramphenicol (higher ratio of deoxyribonucleic acid/protein than in non-treated cells) was biologically active and increased the number of sensitive sites in the bacterium[1] An additional possibility considered was that pretreated cells, unbalanced in macromolecular constituents, were in special physiological states such that the probability of overcoming X-ray induced lesions was increased Using cells in the several unbalanced states with regard to protein, deoxyribonucleic acid, and ribonucleic acid levels we have studied deoxyribonucleic acid synthesis after X-ray exposure of such cells In the present work results are presented which show (1) An inhibition by chloramphenicol of phasing or 'synchronization' of the deoxyribonucleic acid-synthesizing system and (2) that the radiosensitivity of the synthesizing mechanism is altered by previous chloramphenicol exposure

The conditions for obtaining log phase as well as establishing 'unbalanced phase' growth were those previously described[1] Following the various treatments to be described for obtaining unbalanced growth, the cells were cooled in an ice-bath, harvested, washed and resuspended in cold minimal-salts–glucose medium to give a final concentration of about 20 times the original number (1–2 × 10^{10} cells/ml) in order to obtain satisfactory levels of material for chemical analysis The concentration of cells during exposure was higher than the level used in the earlier studies by a factor of approximately 100 , as a result the number of colony-formers found after a dose of 10,000 r was higher in the experiments reported here[2,3] Following X-ray exposure at ice-bath temperature the cells were added to twice the original culture volume of pre-warmed minimal medium supplemented with 20 μgm /ml thymine and re-incubated with aeration at 37° C Aliquots of this culture were removed at intervals for analysis as detailed earlier[1]

Prior to treatment with 10,000 r of X-rays, log phase *E coli* $15T_{-}$ cells were incubated in minimal medium at 37° C for 1 hr under the following conditions (*A*) incubation in the presence of thymine (normal log-phase cells), (*B*) incubation in the presence of 10 μgm /ml chloramphenicol and (1) plus thymine (increased ribonucleic and deoxyribonucleic acid/protein content), or (2) without thymine (increased ribonucleic acid/deoxyribonucleic acid and protein content) , (*C*) incubation in the absence of thymine (increased ribonucleic acid and protein/deoxyribonucleic acid content)

In normal log-phase *E coli* $15T_{-}$ (condition *A*) exposed to 10,000 r of X-rays, deoxyribonucleic acid synthesis proceeded rapidly for 30–60 min (Fig 1) This was followed by a period in which no net synthesis was detectable In other experiments in which survival was higher than that found in the experiment from which the data of Fig 1 were taken, renewed synthesis was sometimes seen by 90 min The number of colony-forming cells in the irradiated suspensions (10–25 per cent of the controls) remained constant or showed a slight decline during the first 30 min A rapid increase then occurred that probably accounted for the renewed synthesis observed in some experiments

When chloramphenicol was added to log-phase cells (condition *B*1) ribonucleic and deoxyribonucleic acids continued to accumulate while protein synthesis was largely inhibited[1] Such cells washed free of the antibiotic and re-incubated in a thymine-supplemented minimal medium showed a delay of approximately 30 min before net deoxyribonucleic acid synthesis was resumed (Fig 1) When the washed cells treated with chloramphenicol were exposed to 10,000 r of X-rays and then resuspended in thymine-supplemented medium no net increase in deoxyribonucleic acid content was observed during the 2 hr the cultures were studied (only the first 90 min are shown in Fig 1) A similar result was found for cells washed free of thymine prior to incubation in thymine-free minimal medium to which chloramphenicol has been added (condition *B*2) During such incubation only ribonucleic acid was observed to accumulate in large amounts during the 1 hr exposure to the antibiotic[1] As seen in Fig 2, deoxyribonucleic acid synthesis in such cells was completely suppressed after X-ray exposure

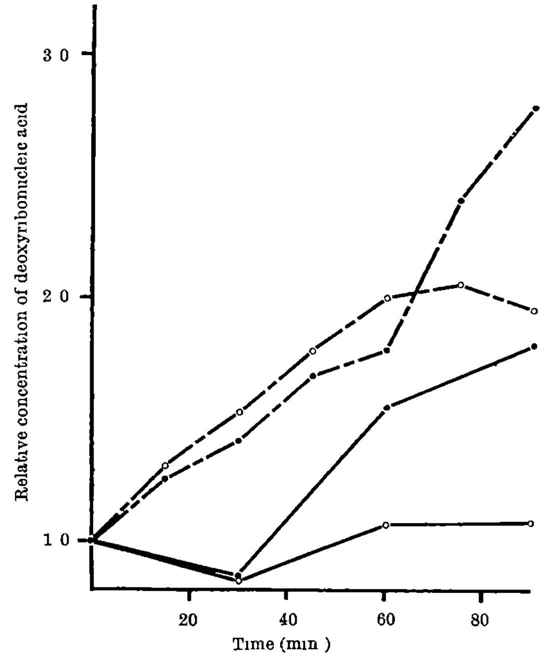

Fig 1 The influence of prior chloramphenicol treatment on subsequent deoxyribonucleic acid synthesis Prior to treatment with 10,000 r of X-rays, log-phase *E coli* $15T_{-}$ cells were incubated for 1 hr under the following conditions ●- - -●, normal log-phase cells (condition *A* of text) , ○- - -○, condition *A*, and then exposure to 10,000 r , ●——●, exposed to chloramphenicol (condition *B*1) , ○——○, condition *B*1, then exposure to 10,000 r

Log-phase cells, washed free of thymine and then re-incubated for 1 hr at 37° C in thymine-free minimal medium (condition *C*), showed a marked increase in ribonucleic acid and protein nitrogen while deoxyribonucleic acid synthesis was essentially nil[1] This was the 'unbalanced growth' reported for this strain of *E coli* by Barner and Cohen[4] Following this treatment the cells, after harvesting and washing at ice-bath temperatures, appeared to be synchronized[5] with respect to deoxyribonucleic acid synthesis (Fig 2) The deoxyribonucleic acid nearly doubled in 30 min This was followed by a period of reduced deoxyribonucleic acid synthesis before a new rate of deoxyribonucleic acid accumulation was seen X-irradiation did not greatly alter the synthesis during the initial doubling period (Fig 2) However, after this initial burst no further increment was found during 120 min of observation The loss of acid-insoluble deoxyribonucleic acid observed in the irradiated cell culture after 60 min was due to lysis of a portion of the cells as reflected by a decreased turbidity of the cultures as well as a reduction in the harvested cell yield (protein) The surviving cells did not grow at a sufficiently

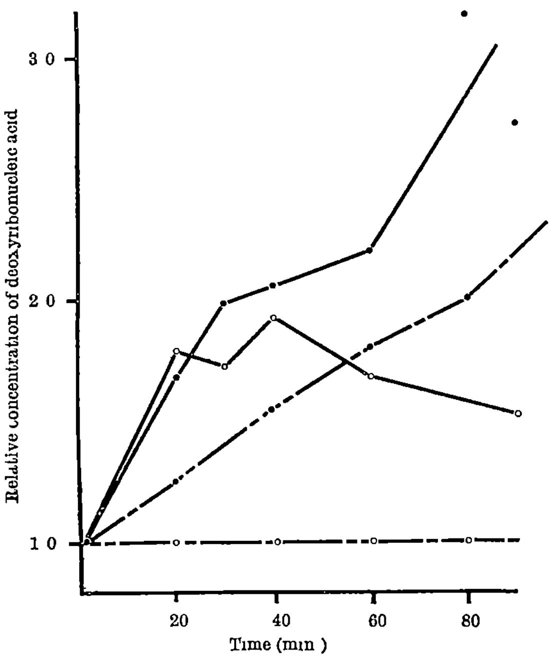

Fig 2 The effect of thymine starvation during chloramphenicol exposure on subsequent deoxyribonucleic acid synthesis Prior to treatment with 10,000 r of X-rays, log-phase *E coli* $15T_-$ cells were incubated for 1 hr under the following conditions ●——●, incubation in the absence of thymine (condition *C* of text), ○——○, condition *C*, and then exposure to 10,000 r ●---●, exposed to chloramphenicol in the absence of thymine (condition *B*2), ○---○, condition *B*2, and then exposure to 10,000 r

rapid rate to be reflected in the analysis during these 2 hr It required more than 2 hr for dividing survivors to reach the initial level of unirradiated cells of the controls

Thus, during the incubation in the absence of thymine (condition *C*), a radioresistant synchronization of deoxyribonucleic acid appeared to have occurred Similar treatment did not synchronize ribonucleic acid or protein synthesis[6] The addition of chloramphenicol to such cells prevented the development of the radioresistant system synthesizing deoxyribonucleic acid It is also apparent that the addition of chloramphenicol to log-phase *E coli* $15T_-$ incubated in the presence of thymine resulted in a physiological state such that deoxyribonucleic acid synthesis did not occur immediately after removal of the antibiotic Cells in this physiological state could not synthesize deoxyribonucleic acid until a radiosensitive process had been initiated Although the mechanism whereby chloramphenicol brings about this effect is unknown, it is tempting to speculate that the antibiotic-induced inhibition of protein synthesis was involved The protein (and/or ribonucleic acid) synthesized in a given time period (in the presence or absence of net deoxyribonucleic synthesis) may be a necessary prerequisite for subsequent deoxyribonucleic acid synthesis One may envisage this protein as being involved in the formation of a template[7–10] or as specific enzymes perhaps similar to the polymerases described by Kornberg and collaborators[11] which were found to be capable of *in vitro* deoxyribonucleic acid synthesis Additional experiments planned may provide further insight into the true nature of the radiosensitive process inhibited by chloramphenicol

The results with irradiated *E coli* $15T_-$ correlate well with the findings of others in plant[12] and animal[13,14] studies that there is a radiosensitive process involved in deoxyribonucleic acid synthesis which is not the deoxyribonucleic acid replication system itself The radiosensitive process occurring prior to actual deoxyribonucleic acid synthesis may involve protein synthesis as suggested from the results presented here Log- or stationary-phase cell suspensions when exposed to X-rays contain organisms in various phases of their division cycle One may speculate that there occurs, in normal growth of individual cells, a phase such that the products of the radiosensitive process are exhausted and must be synthesized anew before deoxyribonucleic acid replication can proceed If most cells of an exposed population were in the active deoxyribonucleic acid synthesizing (radioresistant) phase they would continue to make deoxyribonucleic acid until a predetermined level would have been reached Therefore at doses of X-rays in which most of the population no longer were colony-forming cells a good amount of deoxyribonucleic acid as well as ribonucleic acid and protein synthesis would occur[6] The extent of deoxyribonucleic synthesis would be determined by the length of the deoxyribonucleic synthetic period relative to that of the sensitive pre-synthetic phase In a log-phase population most cells would be in the deoxyribonucleic acid synthesizing phase if this period occupied most of the division cycle of the cell Based on this model our results would suggest that most log-phase cells are not in the radiosensitive period since irradiated populations increased significantly their deoxyribonucleic acid-levels upon reincubation The radiosensitive pre-synthetic process, having been inhibited by radiation exposure, would no longer function and thus deoxyribonucleic acid synthesis would come to a close if it is assumed that the radiosensitive process is permanently inhibited by irradiation When sufficient numbers of survivors were present these would grow at a rate reflecting their physiological state prior to exposure and eventually produce measurable amounts of deoxyribonucleic acid If the number of survivors were high enough and exhibited little lag upon resuspension in a complete growth medium they would produce sufficient amounts of deoxyribonucleic acid to be measurable soon after exhaustion of deoxyribonucleic acid synthesis in dying cells Thus the termination of deoxyribonucleic acid synthesis in dying or dead cells would be masked by the dividing viable cells At higher doses of X-irradiation deoxyribonucleic acid synthesis may be completely suppressed by the destruction of the radioresistant deoxyribonucleic acid synthesizing mechanism itself[6]

[1] Billen, D , *Biochim Biophys Acta* (in the press)
[2] Stapleton, G E , Billen, D , and Hollaender, A , *J Bacteriol* , **63**, 805 (1952)
[3] Gunter, S E , and Kohn, H I , *J Bacteriol* , **72**, 422 (1956)
[4] Barner, H D , and Cohen, S S , *J Bacteriol* , **71**, 149 (1956)
[5] Barner, H D , and Cohen, S S , *J Bacteriol* , **72**, 115 (1956)
[6] Billen, D (unpublished work)
[7] Draculic, M , and Errera, M , *C R Soc Biol* , *Paris*, **152**, 1208 (1958)
[8] Stent, G S , "Advances in Virus Research", **5**, 95 (1958)
[9] Doudney, C O , and Haas, F L , *Proc U S Nat Acad Sci* , **43**, 871 (1958) *J Molecular Biol* (in the press), *Proc U S Nat Acad Sci* (in the press)
[10] Harold, F M , and Zipporin, Z Z , *Biochim Biophys Acta*, **29**, 439 (1958)
[11] Lehman, I R , Zimmerman, S B , Adler, J , Bessman, M J , Simms, E S , and Kornberg, A , *Proc U S Nat Acad Sci* , **44**, 1191 (1959)
[12] Howard, A , and Pelc, S R , *Heredity*, **6**, Supp , 261 (1953)
[13] Ord, M G , and Stocken, L A , *Nature*, **182**, 1787 (1958)
[14] Lajtha, L G , Oliver, R , Berry, R., and Noyes, W D , *Nature*, **182**, 1788 (1958)

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ASSISTANT LECTURER (with an honours degree in geology and with ability to lecture in historical geology and micro-palæontology) in GEOLOGY at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (September 30)

ASSISTANT LECTURER IN SOCIAL ADMINISTRATION—The Registrar, The University, Manchester 13 (September 30)

ASSISTANT LECTURERS IN BOTANY—The Registrar, The University, Manchester 13 (September 30)

CHAIR OF EDUCATION in the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (September 30)

SENIOR LECTURER IN THE DEPARTMENT OF GEOPHYSICS at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (September 30)

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Commonwealth Bureau of Animal Nutrition Rowett Research Institute, Bucksburn Technical Communication No 20 Diet in Relation to Reproduction and the Viability of the Young Part 2 Sheep—World Survey of Reproduction and Review of Feeding Experiments By W Thomson and F C Aitken Pp 93+appendix (Farnham Royal, Slough Commonwealth Agricultural Bureaux, 1959) 30*s* [125

Proceedings of the University of Durham Philosophical Society Vol 13, No 10 The Collision of Particles in Suspension in a Fluid Stream By E G Richardson Pp 89–97 Vol 13, No 11 Construction of a sensitive Temperature Controlled Torsional Pendulum By E W Dickson and N Thorley Pp 98–107 (Durham University of Durham Philosophical Society, 1959) [125

University of Leeds, Publications and Titles of Theses, 1956–1957 Pp 77 (Leeds The University, 1959) 6*d* [125

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General Register Office Studies on Medical and Population Subjects No 15 Social and Biological Factors in Infant Mortality By J A Heady and M A Heasman Pp viii+195 (London H M Stationery Office, 1959) 20*s* net [225

The Annual Review of the Solartron Electronic Group for the year 1958 Pp 28 (Thames Ditton The Solartron Electronic Group, Ltd , 1959) [225

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Journal of Applied Polymer Science, Vol 1, No 1, (January-February, 1959) Pp 127 Published bi-monthly, covering two volumes annually Subscription price, 17 50 dollars per volume Foreign postage 0 50 dollars per volume (New York Interscience Publishers, Inc , London Interscience Publishers, Ltd , 1959) [55

Carnegie Institution of Washington Annual Report of the Director of the Department of Terrestrial Magnetism, 1957–1958 Pp ii+95–166+6 plates (Reprinted from *Carnegie Institution of Washington Year Book 57*, for the year July 1, 1957—June 30, 1958) (Washington, D C Carnegie Institution of Washington, 1958) [55

United States Atomic Energy Commission Technical Information Service Technical Book sponsored by the U S Atomic Energy Commission Pp 40 (Washington, D C United States Atomic Energy Commission, 1959) [55

General Systems Yearbook of the Society for General Systems Research, Vol 3, 1958 Edited by Ludwig von Bertalanffy and Anatol Rapoport Pp xxiii+259 (Ann Arbor, Michigan Society for General Systems Research, Mental Health Research Institute, University of Michigan, 1958) [55

Achtzehnter Jahresbericht der Schweizerischen Gesellschaft fur Vererbungsforschung, Société Suisse de Génétique (S S G), 1958, mit Unterstutzung der Julius Klaus-Stiftung fur Vererbungsforschung, Sozialanthropologie und Rassenhygiene in Zurich Pp 116 (Separatabdruck aus Archiv der Julius Klaus-Stiftung fur Vererbungsforschung, Sozialanthropologie und Rassenhygiene, Band 33, 1959, Heft 3/4) (Zurich Art Institut Orell Fussli, 1959) [55

World Health Organization Technical Report Series No 168 Hypertension and Coronary Heart Disease Classification and Criteria for Epidemiological Studies—First Report of the Expert Committee on Cardiovascular Diseases and Hypertension Pp 28 (Geneva World Health Organization, London H M Stationery Office, 1959) 1 Swiss franc, 1*s* 9*d* , 0 30 dollars [55

Mauritius Sugar Industry Research Institute Annual Report 1958 Pp 103+xxviii+42 figures (Réduit Mauritius Sugar Industry Research Institute, 1959) [125

Transactions of the American Philosophical Society New Series, Vol 49, Part 3 Aleut Dialects of Atka and Attu By Prof Knut Bergsland Pp 128 (Philadelphia American Philosophical Society, 1959) 3 dollars [125

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Australian Defence Scientific Service Defence Standards Laboratories Technical Memorandum No 2 The Intensity of Infrared Absorption Bands a Bibliography Compiled by Dr G R Gillis Pp i+48 (Maribyrnong, Victoria Defence Standards Laboratories, Department of Supply, 1958) [125

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Research Council of Alberta Thirty-ninth Annual Report, 1958 Pp 66 (Report No 78) (Edmonton Research Council of Alberta, 1959) [125

Uganda Electricity Board Eleventh Annual Report and Accounts for the year ended 31 December, 1958 Pp 44 (Kampala Uganda Electricity Board, 1959) 5*s* [125

University of California Publications in Botany, Vol 30, No 3 Chromosome Numbers in the Hydrophyllaceae V By Marion S Cave and Lincoln Constance Pp 233–258 (Berkeley and Los Angeles University of California Press, London Cambridge University Press, 1959) 50 cents [125

Fonds National de la Recherche Scientifique, Bruxelles Trente et unième Rapport Annuel, 1957–1958 Pp 278 (Bruxelles Fonds National de la Recherche Scientifique, 1959) [125

Bulletin of the American Museum of Natural History Vol 117, Article 2 Variation in and Distribution of Lizards of Western Mexico Related to *Cnemidophorus sacki* By Richard G Zweifel Pp 57–116+plates 43–49 (New York American Museum of Natural History, 1959) 1 25 dollars [125

Trinidad and Tobago Administrative Report of the Forest Department for the year 1956 Pp 41 (Trinidad Government Printing Office, 1958) 75c [125

Metropolitan Life Insurance Company Statistical Bulletin, Vol 40, (March, 1959) Survival to Age 65 and Beyond Disability Rate Down in 1958 Health Problems in Later Life Loss of Life in Floods—a 30-year Survey Pp 12 (New York Metropolitan Life Insurance Company, 1959) [125

United States Department of Agriculture Leaflet No 389 Cantaloup Insects in the Southwest How to Control Them Pp 8 (Washington, D C Government Printing Office, 1959) [125

East Africa High Commission East African Marine Fisheries Research Organization Annual Report, 1958 Pp 20 (Nairobi Government Printer, 1959) Sh 4 [125

The Snellus Expedition in the Eastern Part of the East Indian Archipelago, 1929–1930 Under the Leadership of P M Van Riel Vol 2 Oceanographic Results Part 8 Chemical Results and a Survey of Water Masses and Currents By H Postma Pp vi+116 Vol 4 Chemical Results Tables Oxygen, Hydrogen Ion, Alkalinity and Phosphate By H Postma Pp vi+116 (Leiden E J Brill, 1959) [125

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Companhia de Diamantes de Angola (Diamang) Servicos Culturais Dundo-Lunda, Angola Publicacoes Culturais No 44 Subsidios para o Conhecimento do Clima da Lunda Resultados das Observações Meteorológicas, (Area das Exploracões da Companhia), Anos de 1952 a 1957 Elaborados por Tomaz Rebelo do Espirito Santo Prefacio do Prof Amorim Ferreira Primeiro Volume Apuramentos Anuais de Estação Meteorologica do Dundo, Postos Climatologicos e Udométricos Pp 307 (Lisboa Companhia de Diamantes de Angola, 1958) [125

Institut Royal des Sciences Naturelles de Belgique Exploration Hydrobiologique des Lacs Kivu, Édouard et Albert (1952–1954) Resultats Scientifiques Vol 3, Fascicule 3 Le Régime Alimentaire des Poissons des Lacs Édouard et Albert (Congo Belge) Par Jean Verbeke Cladocera Par Vincenz Brehm Dermaptera Par W D Hincks Trichoptera du Lac Abert Par Serge Jacquemart Larves de Chironomidae (Diptera Nematocera) Par Anna Chrispeels Bostrychidae (Coleoptera) Par Jean-Marie Vrydagh Pp 196 (Bruxelles Institut Royal des Sciences Naturelles de Belgique, 1959) [225

Board of Grain Commissioners for Canada, Winnipeg Grain Research Laboratory, 1958 Report Pp vi+76 (Ottawa Queen's Printer, 1959) [225

Forest Research Institute, Dehra Dun Indian Forest Leaflet No 154 (Entomology) Results of Experiments on Basal Girdling in Four Species of Timbers in Bihar in Relation to Anti-Insect Protection By M L Roonwal, P N Chatterjee and R. S Thapa Pp i+25 (Delhi Manager of Publications, 1957) Rs 1 50 , 2*s* 3*d* [225

Académie Royale de Belgique Annuaire pour 1959 Pp 251+59+6 planches (Bruxelles Academie Royale de Belgique, 1959) [225

Svenska Linne- Sallskapets Årsskrift, Årg 41, 1958 Pp 154 (Uppsala Svenska Linné-Sallskapet, 1959) [225

Geological Society of America Special Paper No 65 The Floors of the Oceans, 1 The North Atlantic Text to accompany the Physiographic Diagram of the North Atlantic By Bruce C Heezen, Marie Tharp and Maurice Ewing Pp xii+122+30 plates 4 50 dollars Physiographic Diagram 1 50 dollars (New York The Geological Society of America, 1959) [225

Union of South Africa Department of Agriculture Science Bulletin No 377 Investigations on the Composition of South Africa Milk 7 The Compositional Quality of the South African City Milk Supply By S Bakalor Pp ii+117 (Pretoria Government Printer, 1958) 8*s* [225

Commonwealth of Australia Department of External Affairs Australian National Antarctic Research Expeditions A N A R E Reports Series C, Vol 2 Cosmic Rays Cosmic Ray Records, Mawson, 1955 By N R Parsons Pp 59 Series d, Vol 8 Meteorology Mawson and Macquarie Island, 1959 Pp 77 (Melbourne Antarctic Division, Department of External Affairs, 1958) [225

The Year Book of the International Council of Scientific Unions, 1959 Pp 77 (The Hague International Council of Scientific Unions, 1959) [225

Fondation Universitaire Trente-huitième Rapport Annuel, 1957–1958 Pp 148 (Bruxelles Fondation Universitaire, 1959) [225

Proceedings of the United States National Museum No 3411 A Revision of the Milliped Genus *Brachoria* (Polydesmida Xystodesmidae) By William T Keeton Pp 58 No 3413 Notes on Aradidae in the U S National Museum (Hemiptera) 1 Subfamily Calisiinae By Nicholas A Kormilev Pp 209–222 (Washington, D C Government Printing Office, 1958 and 1959) [225

United States Department of Commerce Weather Bureau Technical Paper No 35 Climatology and Weather Services of the St Lawrence Seaway and Great Lakes Prepared by Marine Area Section, Office of Climatology Pp ii+75 (Washington, D C Government Printing Office, 1959) 45 cents [225

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Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for the year ended 31st December, 1957 Pp 20 (Sydney Museum of Applied Arts and Sciences, 1959) [225

South African Council for Scientific and Industrial Research National Building Research Institute Technical Report No 7 Colour and the Child—Colour and Its Contribution to School and Hostel Buildings By R Merle Frean and D M Calderwood Pp vii+27 (Pretoria National Building Research Institute, 1959) [225

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RESEARCH ASSOCIATIONS AND THEIR FUNCTIONS

IN its report for the year 1958, the Council for Scientific and Industrial Research discussed briefly its general policy towards the research associations, expenditure on which, in revenue and capital grants, it envisaged as rising by about a third during the next five years, because their scope and activities are growing steadily in response to the expressed needs of industry The Council's policy, however, is that industry should bear an increasing share of the total operating cost of the associations, and it is envisaged that over the next five years grant-earning income from industry will be 46 per cent greater than during the past five years, while the grants themselves will be only 34 per cent greater For the year ended March 31, 1958, annual grants to the associations totalled £1,700,330, compared with £1,424,830 in the previous year, with special grants of £32,571, compared with £126,954 The total income of the associations is given as just under £7 million It was stated that during the fifteen months ended December 31, 1958, new or revised terms of grant had been awarded to ten of these associations

The new terms are set out in "Research for Industry, 1958"* (see also p 238 of this issue) This report on the work of the industrial research associations includes a summary of the report of the Industrial Grants Committee, which at the request of the Council has surveyed the work done by research associations, and the methods used to assess the applications for grants received from industry The main conclusions and recommendations of this Committee have been accepted by the Council and, besides considering research association grant policy in the period 1957–64, the Committee's report reviews particularly the achievements of the ten associations which have received new or modified terms of grant "Research for Industry, 1958" also includes an assessment by Dr D T A Townend of the place of the research associations in the evolution of scientific endeavour in Great Britain, and a report prepared for the Committee of Directors of the Textile Research Associations on how co-operative research serves the textile industries These two surveys throw rather more light than the new terms of grant on how in practice the Council's new policy is being interpreted

The Industrial Grants Committee was greatly impressed with the rapid progress of research associations towards maturity and with the rising quality of the research they carry out and the services they give to industry The Council is satisfied that co-operative research, as fostered by the Department, is of great value to industry and the nation, and that the Department of Scientific and Industrial Research should continue to give it whole-hearted support All told, the grant-aided organizations in the scheme serve about 55 per cent of British manufacturing industry, and besides basic and applied research their activities include the study of factory operations and working conditions, library and information services and technical and advisory work for individual firms The largest single function is applied research on problems common to the whole of the industry served

The Council also endorses the Committee's view that co-operative research brings important specific benefits to industry, economizing on money and scientific man-power, and offering a scientific service to firms that cannot afford research departments of their own It helps to guide industry towards an appreciation of the value of research in general and facilitates an exchange of technical information and other forms of mutual assistance Finally, it builds up a store of knowledge on which the nation, through Government departments, can draw

These are large claims, some of which have been challenged, at least to the extent of asking whether certain functions could be more efficiently served in other ways or by changing the technical character of the associations themselves Nevertheless, their acceptance by the Council seems to dispose of any suggestion that the Council is intending to wind up some of the research associations Indeed, it is specifically stated that the expansion contemplated over the next quinquennium allows for an increase in their number, since recent estimates of the Department suggest that nearly a fifth of the net output of British manufacturing industry comes from trades which in the Committee's view are not fully covered by existing research facilities Some of these trades might in future be appropriately served by grant-aided research associations

Until the Second World War, Government aid to research associations in Britain was based on the assumption that they would eventually support themselves entirely In 1945, however, it was decided that this policy was no longer in the national interest, and that industrial grants should become one of the continuing activities of the Department The procedure now generally followed is to award a basic 'block' grant and supplement it with an 'incentive' payment which varies (up to a maximum) according to what income an association can raise from its members Aid is generous to a young research association serving an industry which does not yet recognize the full value of research, but, as the association establishes itself and increases both the scale of its work and the contribution science can make to the productivity of its member firms, the incentive is gradually reduced, and it ceases altogether when the association reaches its appropriate size

Even so, Dr D T A. Townend points out that eleven associations have an annual income of less than £50,000 and only two receive more than £500,000 Eighteen have incomes between £50,000 and £100,000, eight between £100,000 and £250,000, and seven between £250,000 and £500,000 These are not high figures for research to-day, and it could be asked whether they are always high enough for efficiency The Industrial Grants Committee is clearly asking the right questions when a grant comes up for review at the end of five years, and the Council accepts its view that it is important to continue paying a block grant after the association has reached an appropriate size

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* Department of Scientific and Industrial Research Research for Industry 1958 a Report on Work done by the Industrial Research Associations in the Government Scheme Pp iv+135 (London H M Stationery Office, 1959) 7*s* 6*d* net

This size obviously must take account of the adequacy of the facilities of an association for effective research, but the Council concurs in the Committee's view that continuance of the block grant will enable the Department to exercise an important and beneficial influence on industrial research and ensure that each association has the necessary proportion of basic research in its programme It is also argued that a channel is thus kept open for the steady flow of research results to Government departments , this helps to prevent undesirable overlapping of projects and to secure desirable co-operation on programmes of wide interest

Before these propositions are accepted, their implications for the Council of Scientific and Industrial Research require examination They presuppose the existence of an administrative structure for which even the Lord President of the Council has disclaimed responsibility Some overlapping should certainly be prevented by the Council for Scientific and Industrial Research , but it should be clear from the discussion aroused by recent proposals for a programme of space research to be undertaken by Britain that there is by no means general agreement that administrative arrangements are yet such as to ensure the minimum of overlapping, much less the most desirable balance and distribution of research effort

Since the policy of reducing incentive grants was adopted in 1951, the overall ratio of grant to industrial income has fallen from 1 · 1 65 to 1 2 5, and the lowest individual ratio is now 1 4 6 There is nothing mechanical about the trend, and although the ratio is not given for the ten associations for which the terms of grant were revised during the past year, the ratio of incentive grant to additional income varies from 1 1 to 1 2, and the maximum incentive grant from £3,000 to £18,000 These figures show, however, that the reduction of incentive grants is being exercised with the flexibility which the Council adumbrates

It is recognized that a long time may be required for an association to convince industry of the value of its work and that if the incentive grant is reduced too quickly, industrial research may be discouraged and the purpose of the grant defeated Likewise, changes in the purchasing power of money have to be considered, particularly when research associations receive only a block grant An allowance to restore the real value of the grants was made in 1955, and the Industrial Grants Committee recommends a similar provision if necessary for the next quinquennium

More important than this question of finance, however, is that of function The Council endorses the Industrial Grants Committee's view that it is very important to keep a proper balance in the activities of the associations between basic research, applied research (including development work) and information, liaison and consultant services In some industries pioneering studies of factory operations and working conditions are best made on a co-operative basis, and the Council believes that research associations should extend this work where conditions are suitable, and that, wherever appropriate, the Department of Scientific and Industrial Research should carry out its research in this field and disseminate the results, in close collaboration with the associations

No indication is given as to what is regarded as a proper balance between the various activities That will naturally vary from industry to industry, as well as with the maturity of the association It is left for Dr Townend to supply a rough estimate as to the proportion of the £7 million of the total income which is spent on fundamental research, though this estimate does not necessarily also indicate the proportion of man-power which is devoted to fundamental research Of a total staff of some 5,000, 1,450 are graduates or possess equivalent qualifications, 1,750 are research assistants, 850 artisans and 950 administrative staff

Both the Council and its Industrial Grants Committee hold that, so long as co-operative research programmes do not suffer, research associations should be encouraged to undertake a reasonable amount of sponsored research Some associations are already prepared to do so, and generally have a small proportion of their staff engaged in this way The practice offers definite advantages in giving research workers useful experience and in strengthening the contact between research associations and industry

The Council insists, nevertheless, that the chief task of the research associations is co-operative research and that there are other facilities for sponsored research, offered by private bodies without Government assistance It would welcome increased participation by research associations in sponsored research, but such activities must be kept within reasonable limits In future a grant-aided association is free to undertake sponsored projects without consulting the Industrial Grants Committee provided the income arising is unlikely to exceed 15 per cent of total income in any year, and that the estimated cost of any one project is not more than £5,000

Dr D T A Townend's review examines this question of function a little further He points out that the present total income of the research associations in Britain, namely, £7 million, must be compared with the expenditure of private industry on research and development of £58,000,000, or 0 8 per cent of industrial output , and this £7 million is less than half the £14 4 million expended on research undertaken within the universities in science, technology, medicine and agriculture, towards which the Government provided about £12 million The universities are mainly concerned with extending the frontiers of scientific knowledge in an atmosphere of intellectual freedom and usually without regard to the immediate and specific applications of their work Industrial laboratories, he suggests, are mostly devoted to study of the processes and products of a particular firm, with the object of developing something which that firm can do, and will do, probably to the exclusion of others

That the last proposition should not be accepted without qualification does not, however, affect the validity of Dr Townend's claim that the research associations are in a unique position to pinpoint the research problems of importance to the whole of their respective industries The validity of that claim depends rather on the effectiveness of their contact with the industries they serve, their ability to recruit and retain staff of appropriate experience and ability, and on the quality of their directorate Some of these factors can be influenced by the Council for Scientific and Industrial Research, but only to a limited extent, and they should be borne in mind in considering Dr Townend's argument There is a separate domain between the universities and industry, he argues, in which knowledge of the basic principles of industrial processes has to be sought with a particular and definite objective This region accordingly is mostly unsuitable for the universities and is also somewhat too long in range or too expensive, at least for the smaller industrial firms in their own laboratories This, he claims, is particularly the domain of the research associations, with their resources and teams of scientists capable of covering a variety of disciplines with a character and individuality of their own There is no fuss about claiming freedom of action—the Industrial Grants Committee is emphatic as to the need for preserving the autonomy of the associations—nor are unattractive features of the field of investigation neglected

Dr Townend believes that industry in Britain has been well served by the research associations for many years in a well-defined field uniquely appropriate to the associations, with no fear of overlap, and he also suggests that the practice in most associations of pursuing both long-range and short-range objectives side by side contributes to the long-term future of the industries they serve, as well as to the virility of the overall activity of the associations As to the balance of research, Dr Townend refers to a recent survey of the activities of some thirty-two associations, which showed that the proportion of effort devoted to basic research varied from 10 per cent to 67 per cent, the average being about 28 per cent, whereas that devoted to applied research averaged 63 per cent Close contact has almost invariably been established between the associations and the universities, wherever research work of relevance to that of the association is already undertaken at universities Sometimes the associations assist university departments by contracts or by financing fellowships or bursaries, and this assistance may be given to an existing programme in a university department, or an association may seek to arouse the interest of a university department in a new subject Dr Townend appears to be satisfied that these arrangements are adequate They increase the 'thinking potential' of an association and help to relate the work of university scientists to the needs of industry Often they are particularly effective in ensuring that university workers are provided with a correct translation of an industrial problem into scientific terms, and they supplement the necessarily limited results obtained by postgraduate students with ancillary measurements and background information, thus enabling the results of the work to be applied more readily What is not specifically stressed is the atmosphere for research which the associations could provide and which was rightly stressed by Mr J Wilson in his Hinchley Memorial Lecture last year, and this atmosphere is one which the Council for Scientific and Industrial Research could certainly foster

Clearly the interchange of staff between the research associations and the universities can be beneficial here, but Dr Townend notes that such transfer has decreased in recent years, possibly in consequence of the general shortage of scientists and of the rapid growth of departments of science and technology within the universities This interchange could well be as important as the interchange of staff between the associations and industry itself, and valuable as may be the contributions of the associations in research, they will only render their full service to industry when such interchange of staff proceeds freely and to the maximum extent It can be an important factor, as Dr Townend notes, in supplying industry with senior staff at the managerial as well as the technical level, and the educational potential of the associations is not the least reason for justifying the continuance of support from the Department of Scientific and Industrial Research There may well be scope for further specific development of the training potential of the associations without interfering with their primary and main function of co-operative research It should be clear, however that if they are to render their full contribution to industrial development, they must be assured not only of wise and far-sighted leadership, but also of sustained financial support, probably on a more generous scale than the resources at present available to the Department of Scientific and Industrial Research have yet permitted.

ROCKETS AND SATELLITES

Manual on Rockets and Satellites

Edited by L V Berkner, in association with Gilman Reid, John Hanessian, Jr, and Leonard Cormier. (Annals of the International Geophysical Year, Vol 6) Pp xx+508 (London and New York: Pergamon Press, 1958) 160*s*

THERE is little doubt that this volume of the Annals of the International Geophysical Year contains the most comprehensive account yet published of the researches being carried out and the methods and techniques being used in the fields of rockets and satellites Any book dealing with such a young and rapidly growing subject will inevitably date rather quickly, and it so happened that the launching of the first Russian Earth satellite occurred at a very late stage in the preparation of this work. The preliminary account of the Russian results, and the rapid switch in the emphasis of the American satellite programme from the *Vanguard* to the *Explorer* series, are dealt with rather briefly in annexes. It is perhaps fortunate that we have on record here, written before it was overtaken by events, the American plan for the scientific programme intended for the *Vanguard* satellites.

Viewed as a whole the volume cannot fail to be an invaluable source of reference to workers in the field. The upper atmosphere research rocket which still has a vital part to play is not neglected, but the greater part of the book is devoted to Earth-satellite programmes and plans. Those whose interest is more general will gain an insight into the complexities of planning and the widespread co-operation needed in a space research programme, in addition to a sober review of the many new avenues of scientific research now being opened. The volume takes the form of a series of scientific papers, covering subjects as diverse as the design of instruments for many rocket- and satellite-borne experiments, and the organization of volunteer visual observing teams, both in the United States and in the U.S.S.R. It is indeed pleasing to find an international flavour throughout, with significant contributions from the U.S.S.R.

The book is handsomely produced and illustrated, as is to be expected for the price. One must hope that the end of the International Geophysical Year itself will not prevent the compilation of further authoritative international volumes in these expanding fields.

MICROCOSM TO MACROCOSM

Matter, Earth and Sky

By Prof. George Gamow. Pp. xi+593. (London: Macmillan and Co., Ltd., 1959.) 50*s*. net.

EXUBERANT and encyclopædic are the only terms to describe this interpretation of the material universe, most appropriately dedicated to "Aspiring Youth". In the days of stone-turning and avenue-exploring, barriers had to be either surmounted or torn down; Prof. Gamow himself was the first to realize that with the right kind of approach nothing so drastic is needed, and that they can be gently tunnelled through. There is certainly a barrier between the experience of the ordinary individual and the physicist's interpretation of it. In this book, without demanding excessive penetration on the part of the reader, the author has successfully brought into the open the truths that occupy the inner levels of the well.

The style follows the author's usual successful formula—saying what comes naturally. There are some old friends, including C. G. H. Tompkins, translated to an American setting, but still on a communal Cambridge bicycle. The illustrations are excellent, original and relevant—even those that are put in just for fun, like the one showing an 'experiment' on the thermal expansion of a body, which looks rather unkind. Scientists are pictured with a richly human touch—Otto Hahn registering sheer amazement at the fission of uranium, Compton strumming his banjo with effect, and Bohr in orbit on a motor-cycle.

The book is divided into three sections. The first, on "Matter and Energy", deals with the elementary physics of the surroundings, relating everyday observations to fundamental principles. This ranges widely from simple mechanics to computers and satellites and rocketry and relativity. The second, entitled "Microcosm", starts with the kinetic view of matter in terms of molecules, and covers atomic and nuclear physics, and a good deal besides. The chapter on the chemistry of life, which goes very fully into protein structure, and discusses Watson and Crick's model of the structure of deoxyribonucleic acid and its implications for the possible working of heredity, is important both for its contents and its influence on the young reader who may (though not if he has got so far through the book) tend to regard physics as a little remote from living. The third part, "Macrocosm", deals with the Earth and its history, the planets, the evolution of the stars, the origin of the elements and of the galaxies, and the recent theory of continuous creation.

So much could not have been achieved in a single book without very careful planning of the sequence of material, and much skill has been devoted to placing the discussion of a fundamental topic in relation to the general framework. Electrolysis, for example, appears in the second part, where the electrical nature of matter is treated. This means that it is a book to be read through, without dodging back to the beginning for explanations.

It is a splendid book, and highly to be recommended to the general reader and for the library. Although very good value for money, its price unfortunately places it high up in the gift-book class. The unkind experiment mentioned above supposes the co-operation of a good-natured relative, and any aspiring youth who can get such a one in an expansive mood would be well advised to clamour for this book as a present instead.
G. R. NOAKES

SURVEYS IN 'APPLIED' MATHEMATICS

Some Aspects of Analysis and Probability

By Irving Kaplansky, Marshall Hall, Jr., Edwin Hewitt and Robert Fortet. (Surveys in Applied Mathematics, Vol. 4.) Pp. xi+243. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 72*s*. net.

THIS book is the fourth of John Wiley's "Surveys in Applied Mathematics"; its production was sponsored by the United States Office of Naval Research and by the editorial board of "Applied Mechanics Reviews"; its authors are described as being, and indeed are, "internationally recognized authorities in the areas of applied mathematics covered by their surveys". Hall writes on combinatorial analysis, and Fortet on probability theory, while functional analysis and abstract harmonic analysis are surveyed respectively by Kaplansky and Hewitt. An English reader, accustomed to the rigid division between applied mathematics (where nothing is proved) and pure mathematics (where nothing is useful) may well find the classification puzzling. Only the probabilist will be untroubled by it; his subject, having an axiomatic foundation and yet deriving all its inspiration from practical problems, has no place in the traditional classification , he will be quite happy in the applied mathematical club so long as the topological-algebraists are there to keep him company

Kaplansky's article (32 pages) is the shortest in the book, but is supported by a magnificent bibliography of 113 entries, nearly half of them concerning papers by Russian authors , he gives a remarkably clear and concise account of many topics of current interest in the theories of Banach spaces, locally convex spaces and Banach algebras

Hall's survey of combinatorial analysis will be of value not only to algebraists but also to statisticians interested in the existence and construction of designs and to the industrial mathematician concerned with linear programming For the latter there is a fascinating chapter on the theorems of Philip Hall, Konig and Ramsey, and their applications , these include the transportation problem, the travelling-salesman problem, and also such curiosities as the following (Erdős and Szekeres, 1935) "There exists an integer-valued function $N(n)$ of the integer variable n such that every set of N points in the plane, no three on a line, will contain n points forming a convex n-gon"

Hewitt's long article on abstract harmonic analysis presents a connected account of a difficult and important field, which is the more valuable because a large number of the most important papers reviewed here were published in Russian Readers of the older text-books on Lebesgue integration encounter theorems of two kinds those which make essential use of the group structure of the real line, and those which do not Those which do not (for example, the Lebesgue convergence theorems) properly belong to measure theory, while those which do (for example, theorems about convolutions, and the whole of the Fourier theory) can nearly all be generalized to the situation in which the real line is replaced by a (say, abelian) locally compact group and Lebesgue measure is replaced by Haar measure, and this is the situation with which abstract harmonic analysis is concerned

Fortet gives a most valuable account of a number of special topics in probability theory, of which the most characteristic is development of techniques for handling random elements of general type A probability space is a non-vacuous set Ω, a Borel field $\mathcal{F}$ of 'measurable' subsets of Ω, and a totally finite measure μ on $\mathcal{F}$ normalized so that $\mu(\Omega) = 1$ A random variable $x(\ )$ is a mapping from Ω to the real line such that all counter-images of real intervals are $\mathcal{F}$-measurable, and an n-dimensional random variable is defined similarly The classical theory was concerned exclusively with finite sets of such random variables , the modern theory of stochastic processes is concerned with infinite sets of random variables, suitably parametrized, and the theory of general random elements is concerned with (in the first instance single) random variables $x(\ )$ where now the range of the mapping $\omega \rightarrow x(\omega)$ lies not on the real line nor in n-dimensional euclidean space, but in some more general topological-algebraic structure For example, Mourier and Fortet have studied random variables taking values in a Banach space, and Gel'fand has studied random (Schwartz) distributions In a sense the distinction between stochastic processes and general random elements is artificial, for if $\omega \rightarrow x(t,\omega)$ (for each t in some parameter set T) is a set of random variables constituting a stochastic process, then $\omega \rightarrow x(\ ,\omega)$ can be thought of as a general random element, and conversely most of the general random elements one wishes to consider in practice (random age-distributions, random energy-spectra, etc) can be reduced to systems of numerical random variables But the direct treatment of a random variable of general type, where possible, offers many attractions, and there can be no doubt that this branch of the subject will attract considerable attention during the next few years

The publishers are to be congratulated both on the quality of the surveys included in this volume and on their decision to publish this group of four surveys together D G KENDALL

FUTURE MARINE BIOLOGICAL RESEARCH

Perspectives in Marine Biology

A Symposium held at Scripps Institution of Oceanography, University of California, March 24–April 2, 1956 Edited by A A Buzzati-Traverso Pv xvi + 621 (Berkeley and Los Angeles University of California Press , London Cambridge University Press, 1958) 75*s* net

"APPROXIMATELY 90 to 95 per cent of all biologists are engaged in terrestrial biology. . These biologists have a tendency to consider Marine Biology as a somewhat secondary biological annex " P Drach (p 603 *et seq*) further states that general biology can never be properly balanced if based predominantly on terrestrial forms, however important they are to our welfare, a view shared by many of the contributors The expansion of marine biology is reflected by the wide range of subjects presented at a symposium planned to focus attention on forthcoming fields of marine research It is significant that a number of contributions come from non-marine biologists Forty-one papers, with subsequent discussions, are arranged in four sections : ecology , physiology and biochemistry , behaviour , evolution and genetics

Ecological papers by P Drach, L Zenkovitch, G Thorsen, A C Hardy and others, while emphasizing that more field observations on animal communities are required, show the urgent need for new design and international standardization of instruments and techniques for quantitative sampling Field observation is so much stressed that K M Rae's plea, echoed elsewhere, for laboratory observation and experiment on marine equivalents to the guinea pig and fruit fly stands out from the rest D P Wilson's studies on the ability of organisms to detect factors at present defying analysis, and so select a particular substrate, are stimulating Further emphasis on this need for study on microconstituents is given by S K Kon (vitamins and external metabolites), D I Arnon (micronutrients) and L Provasoli (growth factors of marine algae) E Baldwin's paper on biochemical perspectives and the need for more biochemists in marine research is timely

Papers on reef-building corals (C M Yonge) , productivity, patchiness and succession in plankton (W Rodhe *et al* , R Margalef, A C Hardy, L Tonelli and V Tonelli) , cell chemistry (E S G Barron, A Szent-Gyorgyi) , biological clocks (C S Pittendrigh, F A Brown, jun) show the variety of future problems That the section on behaviour consists of four papers as compared with twelve or thirteen of the other sections emphasizes our lack of knowledge W H Thorpe's excellent discussion of ethology indicates the vast amount of data awaiting discovery by simple observation assisted by aqualung, television and camera , and T H Waterman's contribution on underwater polarization patterns suggests many new ideas about plankton behaviour

If the biochemist is rare in marine biology how much more the geneticist Yet D L Ray shows that many species are suitable for genetical study, while papers by V L Loosanoff and Y Matsui point the way to controlled shellfish breeding and farming Geographical distribution, races, speciation of pelagic forms where there appears to be no barrier to gene flow, are challenging problems to all

This book is not just a list of problems for the future Most contributors base their speculations on accounts of present work, much of it unpublished Many contributions are of immediate concern and it is regretted that it has taken more than two and a half years to produce a book that one might expect —and hope—will soon be out of date Errors are few, the chief being the transposition of legends to text-figures 2 and 12 in Hardy's paper, while the last two lines to the legend of text-figure 1 of Bogorov's paper should read "continuous line indicates quantity of phytoplankton and broken line quantity of zooplankton" That the contributions are contained in 621 pages is largely due to the small type, but it remains easy to read and the tables and figures are well set out Non-marine biologists would do well to read this book for much of it has general biological implications

J A ALLEN

HETEROCYCLIC CHEMISTRY

Heterocyclic Chemistry

An Introduction By Prof Adrien Albert Pp viii+424 (London The Athlone Press, University of London, 1959 Distributed by Constable and Co , Ltd) 45*s* net

Six-Membered Heterocyclic Nitrogen Compounds with Three Condensed Rings

By C F H Allen, in collaboration with G M Badger, Brice Graham, G A Reynolds, James H Richmond, John R Thirtle, J A Van Allan and C V Wilson (The Chemistry of Heterocyclic Compounds a Series of Monographs, Vol 12) Pp xxii+624 (New York Interscience Publishers, Inc , London : Interscience Publishers, Ltd , 1958) 196*s*

CHEMISTS in general and students in particular have long been in need of a book of reasonable size on heterocyclic chemistry, but the digestion, selection and presentation of the subject have apparently daunted chemists, for Morton's book, published in New York in 1946, has been the only work of note to appear for many years This is not surprising, for our present detailed knowledge of heterocyclic chemistry must exceed in volume that of aliphatic or of aromatic chemistry, and the infinite variety of heterocyclic compounds must cause this difference to become ever greater A work by Prof Albert is therefore warmly welcome, and it is exceptionally interesting to see how he has approached the task of giving a concise account of this subject in 375 excellently printed pages

He has certainly broken completely away from the orthodox treatment, in which each class is usually discussed largely in the order syntheses, reactions, and finally structure on the basis of these two sections Instead, Prof Albert makes primarily an electronic structure approach to the various classes, and also discusses their physical properties, particularly spectra, ionization constants, oxidation-reduction potentials, and dipole moments in considerable (and very valuable) detail, relegating much of the synthetic side to smaller print This makes absorbing reading to the more advanced chemist, but one wonders whether students will both grasp and then continue to visualize the main bulk of heterocyclic compounds as "π-Deficient N-Heteroaromatics", "π-Excessive N-Heteroaromatics", and "π-Excessive O- and S-Heteroaromatics", which form the titles of the author's three main chapters ?

The author has dealt with the problem of condensing the sheer bulk of material partly by confining references to original literature to papers published since 1930, on the ground that these papers will provide sufficient references to earlier work The result can be unfortunate, for an account of fundamental work is often followed solely by a recent reference, which may record comparatively trivial modifications or extensions of the earlier work consequently the student may often lack the means to honour "the memory of the pioneers of heterocyclic chemistry" to which the book is dedicated It is a pity, furthermore, that although two distinct series of volumes on heterocyclic chemistry are still appearing, references are given almost solely to Elderfield's series, and the larger Weissberger series is almost ignored

The reviewer notes with interest the categorical statement that purines synthesized by building a pyrimidine ring on to an iminazole ring "have always introduced a hydroxy- or amino-group in the 6-position" (p 198) Mann and Porter, in 1945, synthesized by this method a number of 1 7-dialkylpurines which did not contain these groups in this position

The fresh approach, the clear lucidity of the presentation, and the author's personal enthusiasm have produced a book which chemists will read with great interest

The other volume, the twelfth to be published in the Weissberger series, is devoted solely to the chemistry of compounds having three six-membered rings fused together, the only hetero element being one or more nitrogen atoms The vast amount of information, carefully classified and coded in about 600 pages, vividly illustrates the reviewer's earlier comment on the expanse of our knowledge of heterocyclic chemistry The book deals with the chemistry of aza- and polyaza-anthracenes, -phenanthrenes and -benzonaphthenes , the amount of work entailed becomes apparent when one recalls that the monazaphenanthrenes alone form a group of five isomers Furthermore, tables are provided enumerating all the known simple and substituted members of each class up to 1952 This vast accumulation of knowledge has required the services of several chemists, and it concludes with an excellent chapter on "The Ultraviolet Absorption Spectra of Polycyclic Heterocyclic Aromatic Compounds" by Prof. G M Badger, of the University of Adelaide. This volume forms an outstandingly valuable addition to the Weissberger series.

F G MANN

Puzzle-Math

By Dr George Gamow and Dr Marvin Stern Pp 119 (London Macmillan and Co, Ltd, 1958) 8*s* 6*d* net

BOOKS of the 'mathematics for fun' type are often neither very mathematical nor very funny, but those who know some of Dr Gamow's earlier writings will expect this volume, in spite of its catchpenny title, to combine amusement with instruction, and they will not be disappointed The thirty-three problems are entertainingly set out, and solved by honest mathematical processes, involving little or no manipulative technique There are some 'chestnuts'—the three travellers with dirty faces, the fly between two approaching trains—but many of the problems are new or not widely known Is a motorist likely to be held up longer at a level-crossing if the track is double than if it is single ? When we ring for a lift, why does it seem to come in the wrong direction more often than not ? A bright student might easily be led to a better appreciation of the fundamental logic of mathematics by reading this cheerful little book T A A Broadbent

Transactions of the International Conference on the Use of Solar Energy

The Scientific Basis, held at Tucson, Arizona, U S A, October 31 and November 1, 1955 (Sponsored by University of Arizona, Tucson, Arizona, Association for Applied Solar Energy, Phoenix, Arizona, Stanford Research Institute, Menlo Park, California) Vol 1 The Available Energy Measurement of Radiation Pp xvi+135 Vol 2 Thermal Processes, Part 1, Section A, Flat Plate Collectors Pp ix+145 Vol 2 Thermal Processes, Part 1, Section B, High-Temperature Solar Furnaces Solar Power Pp v+146–264 Vol 3 Thermal Processes, Part 2, Solar House Heating Solar Water Heating Solar Stoves Solar Distillation Pp x+168 Vol 4 Photochemical Processes Pp xii+187 Vol 5 Electrical Processes Pp xii+132 (Tucson, Arizona The University of Arizona Press, 1958) 12 50 dollars the set

THESE Transactions, containing 85 scientific papers totalling 887 pages, represent one of the most valuable publications on solar energy research It is therefore all the more regrettable that although the conference at which these papers were presented was held late in 1955, publication has been delayed until the end of 1958, and moreover that there is no record of the valuable discussions that took place at the conference

The conference discussed the scientific basis of solar energy research and was followed by the World Symposium on Applied Solar Energy at Phoenix, Arizona The papers at the latter conference, which dealt preferentially with applications, were published in 1956, and the proceedings were reviewed by the writer (*Nature*, 178, 229, 1956), who also described in some detail the general features of both conferences soon after the meetings (*Nature*, 177, 110, 1956)

The present review is therefore restricted to consideration of a few aspects which have since been emphasized as important by the trend of solar energy research in the interval that has elapsed since presentation Interest in the flat-plate type of collector used for water-heating continues, but research is concentrated on the simplification of design and the use of metallic oxide surface coatings to restrict re-radiation of long wave-length and thus enable higher temperatures to be attained The high cost of the silicon photo-cell, which was then newly developed, has as prophesied been reduced to economic competition with electricity from dry cells and is coming into general use for portable radio and telephone equipment, not excluding such objects as space satellites The solar furnace sponsored by the French Government and described by M Trombe in Vol 2 is the most active achievement at present, and similar furnaces have been sponsored by the governments of other countries for testing materials to resist the thermal shock encountered in high-speed rocket flight and space travel

The Transactions are essential to those embarking on solar energy research, or wishing to ascertain the state of knowledge up to very recently Although there have been some remarkable developments since the conference, this set of volumes, which has been compiled by Prof Carpenter of the University of Arizona Observatory, constitutes a record of permanent value H Heywood

The Fundamentals of Statistical Reasoning

By M H. Quenouille (Griffin's Statistical Monographs and Courses, No 3) Pp 169. (London Charles Griffin and Co, Ltd, 1958) 24*s*

A GOOD short book on the basic principles and theory of statistical inference, expository of those parts of the subject on which statisticians are now generally agreed and objectively critical of some of the more controversial lines of thought, would be of great value Such a book appears to have been Mr Quenouille's aim, but he has had indifferent success Few subjects are in greater need of careful choice of every word, yet all too often the writing here is ambiguous or lacking in clarity For example, the opening paragraph of a chapter on testing hypotheses tends to obscure the important distinction between decision theory and scientific inference that Fisher and Barnard have so usefully emphasized in recent years Later in the same chapter "restriction" of errors of both the first and the second kind is said to be essential to a significance test of (surely "of deviations from" would be clearer) a null hypothesis

The first four chapters rapidly survey the concepts of probability, elementary distribution theory, estimation, and hypothesis testing The second half of the book is of a different order of difficulty and of much greater interest Here is an introduction to maximum likelihood and fiducial inference that could well form the basis of a more substantial text and could stimulate further research Mr Quenouille has a gift for devising the illuminating example He has evidently devoted much thought to fiducial distributions, and one wishes that he would undertake the systematic and critical account of this topic that must supplement Fisher's more intuitive approach if it is to attain its proper recognition Unfortunately, the present book is again unsatisfying, not only because of limitations of space but also because too often the reader cannot tell what is part of standard theory, what is a new contribution from the author (possibly deserving more explanation or more detailed reference to other publications), and what is a tentative suggestion for future exploration However, although one may question the wisdom of including some of this material in an introductory book, undoubtedly the more advanced student will value it D J Finney

The Nature of Experience

By Sir Russell Brain, Bt. (The Riddell Memorial Lectures, Thirteenth Series, delivered at King's College in the University of Durham, 12, 13 and 14 May 1958.) Pp. viii+73. (London: Oxford University Press, 1959.) 8*s*. 6*d*. net.

According to the trust deed, the Riddell lecturer is required to discuss "the relation between religion and contemporary development of thought". It is interesting to look back over past titles, and to see how successive speakers have interpreted their task. In this context, how well these discourses—the thirteenth—fit into the series, and maintain their tradition.

The theme is the field of perception, which the author explores with the object of attaining a view sufficiently comprehensive to restrain, if possible, the excessive specialization which is the outstanding characteristic of modern thought. The three lectures are entitled, (1) "Vision and Fantasy", (2) "The Nature of Perception", (3) "Symbol and Image". Some useful notes and references follow at the end.

Sir Russell is a leading neurologist, and one would expect to find a telling picture of mental processes; in the event, this knowledge is linked with rare aesthetic insight.

The first lecture reviews the conventional sense-impressions and their many contrasts with the structure of matter as the physicist knows it. The author believes that the qualities perceived are constructs of our own brains. Of particular interest is the account of abnormal states produced, for example, by mescaline. The second lecture contains a well-balanced review of the objections which have been raised against the writer's theory. In the last lecture, perhaps the most difficult, art is taken "as the embodiment of feelings in perceptual form", and thus embraces that subjective element deep in human nature which raises it, at times, to an image of the Divine.

F. I. G. Rawlins

Kingdom of the Octopus

The Life-History of the Cephalopoda. By Frank W. Lane. Pp. xx+287+48 plates. (London: Jarrolds Publishers (London), Ltd., 1957.) 30*s*. net.

Mr. Lane's book provides a collection of superb photographs for which the amateur naturalist and professional zoologist must be equally grateful. The full bibliography, clearly representing an immense amount of hard work, will be of value to the teuthologist, making available a number of obscure references and enabling him to examine for himself the provenance of the many curious and often entertaining legends and observations embodied in the text, and thus to make his own estimate of their scientific value.

The text has the inevitable failings of one written by an author who has no (and does not claim to have) specialist knowledge of the subject, and for whom it is therefore hard to assess the relative importance of the different facts and concepts which he has collected. Without such evaluation, however, verbally accurate statements can become misleading, and this fault is intensified, in Mr. Lane's book, by a tendency to dramatic presentation which results in important aspects of the subject receiving less full treatment than relatively trivial but striking details. A similar weakness is to be found in the references made to authors in the text. Mr. Lane is most careful to quote his sources; but, too often, equal weight is apparently given to the long-established findings of famous zoologists, to isolated observations scarcely yet verified, and even to statements, not necessarily accurate, introduced casually in the writings of specialists on other fields.

These failings will not diminish the interest which the rich anecdotal material and fine illustrations will rouse in the general reader; but, as a result of them, the book is scarcely suitable for the use of the student who seeks accurate and balanced information, and is not a book to be used for professional teaching without constant checking.

Anna M. Bidder

Die gesunden und die erkrankten Zahngewebe des Menschen und der Wirbeltiere im Polarisationsmikroskop

Theorie, Methodik, Ergebnisse der Optischen Strukturanalyse der Zahnhartsubstanzen samt ihrer Umgebung. Von Prof. W. J. Schmidt und Dr. A. Keil. Pp. 386. (München: Carl Hanser Verlag, 1958.) 48 D.M.

This book is undoubtedly a classic of its kind by authors who are world authorities in this particular field. It deals in the greatest detail with the normal structure of the calcified tissues of the teeth of man and animals, and then proceeds to a consideration of their structure in disease. The study of the calcified tissues of the teeth has always presented considerable difficulty. The two methods which have been used most are microradiography and polarized light. It seems a pity that no attempt has been made in this book to consider microradiography; but there is no doubt that the use of polarized light as here described and the interpretations given make it a very delicate method for this work. Much difficulty has been caused in the past by faults in interpretation arising from form birefringence and the possibility of birefringence arising from the organic matrices of some of these structures, but these are now all explained in detail, giving a proper scientific basis for further study.

This is the only authoritative work on the subject. It is beautifully produced and very well illustrated. No department, dental or zoological, dealing with the structure of normal or diseased teeth can afford to be without it.

A. I. Darling

Hundred Years of the University of Calcutta

Supplement. Pp. xviii+732+95 illustrations. (Calcutta: University of Calcutta, 1957.) n.p.

The Centenary History of the University of Calcutta was reviewed in these columns a little more than a year ago (*Nature*, **180**, 1152; 1957). This massive supplement adds a large volume of material, including descriptive accounts of the 274 colleges which are or have been affiliated with the University; similar accounts of the development and present state of the institutes and departments of the University; a select list of research publications; a list of University and College teachers in 1956; and a record of the speeches and ceremonies with which the centenary was celebrated in January 1957. There are nearly one hundred attractive photographs, chiefly of college buildings. This is the largest University in the Commonwealth—probably in the world—putting itself on record for posterity.

R. S. Aitken

RADIATION MEASUREMENTS TO 658,300 KM. WITH *PIONEER IV*

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Introduction

THE present report comprises: (*a*) the radiation observations obtained with the U.S. deep-space probe *Pioneer IV*; (*b*) a comparison of these observations with those of *Pioneer III* and of the first Soviet cosmic rocket; and (*c*) an interpretative discussion.

The *Pioneer IV* programme was conducted under the same auspices as those for *Pioneer III*. The radiation detectors and the payload assembly were developed, calibrated and tested co-operatively by the Jet Propulsion Laboratory of the California Institute of Technology and by the State University of Iowa. The four-stage rocket vehicle and associated aspects of the enterprise were handled jointly by the U.S. Army Ballistic Missile Agency and the Jet Propulsion Laboratory, and the launching was conducted at the Atlantic Missile Range, Cape Canaveral, Florida.

The radiation 'package' was very nearly identical to the one flown[1] on *Pioneer III* except for one essential change—the Anton type 213 Geiger tube was encased in an additional shield comprising a closed-end cylinder of lead of thickness 4.0 gm./cm.^{2} and an inner cylinder of stainless steel of thickness 0.6 gm./cm.^{2} (Fig. 1). On the basis of extensive laboratory calibrations at the State University of Iowa, the respective Anton 302 Geiger tubes in *Pioneers III* and *IV* had identical characteristics (that is, effective dimensions, shielding, etc.) to within ± 10 per cent (see ref. 1 for further detail).

The purposes of the radiation experiments in *Pioneer IV* were as follows: (*a*) a re-survey of the intensity-structure of the zones of trapped radiation around the Earth, with special interest in temporal changes since December 6 and 7, 1958; (*b*) a crude determination of the absorptivity of the trapped radiation as a function of position in order to increase knowledge of its composition and spectral character; (*c*) a re-determination of the effective extent of the geomagnetic field; (*d*) a search for magnetically trapped radiation in the vicinity of the Moon; (*e*) a re-determination of the cosmic-ray intensity in interplanetary space; (*f*) a search in interplanetary space for 'blobs' of plasma containing particles sufficiently energetic to be detected by the present equipment.

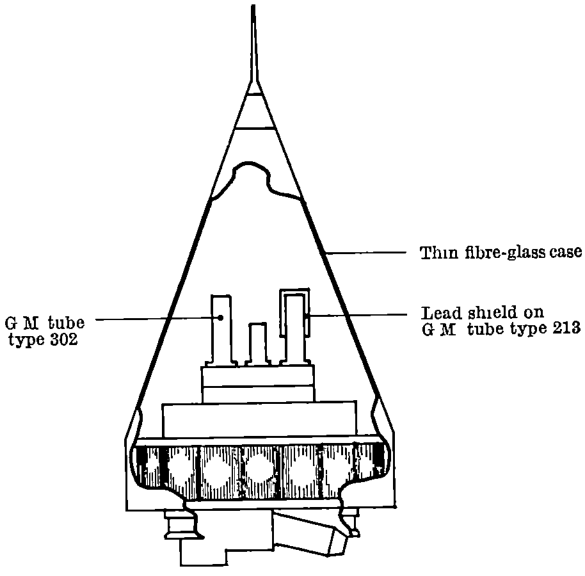

Fig. 1. Physical arrangement of radiation detectors in conical payload of *Pioneer IV*. Base diameter 23 cm. Total payload weight 6.1 kgm. The arrangement of *Pioneer III* was identical except for omission of the shield over the 213 tube

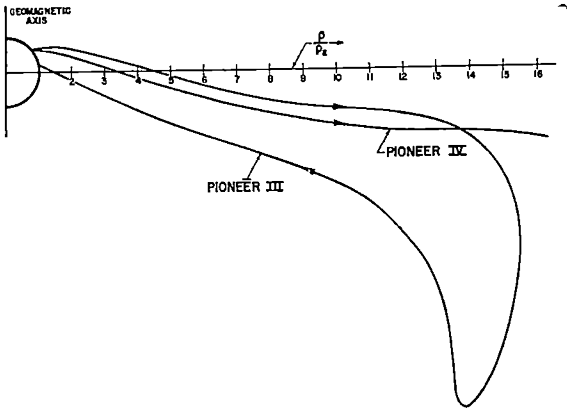

Fig. 2. Plots of the projection of the trajectories of *Pioneer III* and *Pioneer IV* on a geomagnetic meridian plane (centred dipole model). Unit of distance, ρ_E = 6,371 km.

Flight of *Pioneer IV*

Launch from Cape Canaveral, Florida (28.7° N., 80.7° W.) at 05.11 U.T. on March 3, 1959.

Burn-out velocity ('space-fixed'): 11.08 km./sec.

The positional co-ordinates as a function of time were measured by the Jet Propulsion Laboratory tracking array to an uncertainty of some ± 5 km. throughout the region of the trapped radiation and to a slowly increasing uncertainty thereafter. Table 1 lists representative values of the co-ordinates, and Fig. 2 gives a plot of the trajectories of *Pioneers III* and *IV* in the vicinity of the Earth.

Telemetry

The array of Jet Propulsion Laboratory telemetry stations comprised receivers at Cape Canaveral, Florida (5-ft. dish), near Mayaguez, Puerto Rico (10-ft. dish), and at Goldstone Lake, California (85-ft. dish), as before. In addition, there was the valuable Jodrell Bank 250-ft. dish, through the courtesy of Prof. A. C. B. Lovell. The following is a summary of flight periods during which usable radiation observations were obtained.

(*a*) Cape Canaveral
March 3 05 11–05 23 U T

(*b*) Puerto Rico
March 3 05 14–05 52 U T
07 23–15 32

(*c*) Goldstone Lake
March 3 11 58–21 03 U T
March 4 12 34–21 15
March 5 12 40–21 12
March 6 12 53–15 00

(*d*) Jodrell Bank
March 3 06 31–12 24 U T
March 4 07 52–08 08
08 23–08 43
10 42–12 52
March 5 05 41–12 58
March 6 05 42–12 59

From the point of view of the radiation experiment, the only serious loss of data occurred in the period 05 52–06 31 U T on March 3

Beginning at about 14 20 U T on March 6, the strength of the radio signal fell rapidly and no usable data were received after 15 00 U T In view of the rapidity of the decline (in spite of a trivial rate of change of distance) and of its occurrence at about the end of the expected life-time of the batteries, it is presumed that loss of signal at about $x + 82$ hr was due to exhaustion of the mercury batteries in the power supply of the payload The radial distance from the centre of the Earth was 658,300 km at 15 00 U T

Radiation Observations

Due apparently to a high-*g* shock which was recorded during the launching phase, the high scaling factor (2^{17}) element of the 302's scaling circuit did not function in flight This failure gives some cause for uneasiness concerning the proper operability of all other elements of the payload But we have been quite unable to find any evidence for any other malfunction and believe that the results reported below are trustworthy

In Fig 3 is plotted the true counting rate, *R*, of the 302 Geiger tube as a function of time Errors are insignificantly small except where error bars are drawn The constant counting rate beyond 11 10 U T continues without significant variation to the outermost limit of observations Also shown is the equivalent counting rate of the heavily shielded 213 Geiger tube Normalization of the counting rates of the two tubes was done in pre-flight laboratory tests by subjecting them (both unshielded) to identical exposure in a beam of hard X-rays The quasi-d c output of the 213 tube was measured by the audio-frequency of the subcarrier oscillator to which its amplifier was connected A substantial temperature correction was necessary and was made by comparison with another, similarly located oscillator the input of which was digital and the temperature coefficient of which was similar The temperature of the inner portion of the payload rose from a launching value of 15° C to an asymptotic value of 41 5 ± 1 0° C with a time constant of about 3 hr The 302 system had zero temperature dependence over this range In the lower left-hand corner of Fig 3 is plotted as a dashed line the ratio of the equivalent counting rate of the (shielded) 213 tube to that of the 302, this ratio is the apparent transmission, *T*, of the shield The absolute value of *T* is uncertain by some ± 25 per cent of its value due to a combination of systematic errors

In the time-period 06 31–06 53 U T the true counting rate of the 302 may lie either on branch *A* or on branch *B* Such an ambiguity is intrinsic to the characteristic curve of apparent rate versus true rate of the system (cf ref 1) and can be resolved only by auxiliary data The corresponding transmission curves are labelled *A* and *B*, respectively Further discussion is deferred to the next section

In Fig 4 the observations with the nearly identical 302 tubes of *Pioneer III* and *Pioneer IV* are shown as a function of radial distance from the centre of the Earth, ignoring differences of longitude and latitude

Table 1 REPRESENTATIVE VALUES OF POSITIONAL CO-ORDINATES OF *Pioneer IV*

(Bv courtesy of Jet Propulsion Laboratory)

Date and hour (U T)	Geographical latitude	Geographical longitude (E)	Radial distance from centre of Earth	Radial distance from centre of Moon
March 3			(km)	(km)
05 16	28 03°	289 38°	6,679	376,902
05 20	24 49	310 24	7,484	374,585
05 25	18 51	327 98	8,894	371,731
05 30	13 16	339 29	10,518	369,039
05 35	8 90	346 79	12,221	366,532
05 40	5 55	352 00	13,940	364,193
05 45	2 88	355 74	15,646	361,998
05 50	0 72	358 48	17,326	359,927
05 55	−1 07	0 52	18,977	357,960
06 00	−2 57	2 04	20,596	356,084
06 10	−4 95	3 98	23,739	352,556
06 20	−6 77	4 92	26,767	349,272
06 30	−8 20	5 18	29,691	346,184
06 40	−9 37	4 97	32,522	343,255
06 50	−10 34	4 41	35,271	340,460
07 00	−11 16	3 58	37,947	337,779
07 30	−13 03	359 98	45,604	330,280
08 00	−14 34	355 31	52,812	323,400
08 30	−15 31	349 99	59,667	316,982
09 00	−16 07	344 25	66,236	310,917
10 00	−17 20	331 92	78,696	299,593
11 00	−18 00	318 88	90,452	289,070
12 00	−18 61	305 41	101,662	279,139
18 00	−20 53	220 44	161,788	226,753
March 4				
00 00	−21 39	132 74	214,953	180,855
06 00	−21 89	44 07	264,261	138,707
12 00	−22 23	314 91	311,064	100,511
18 00	−22 46	225 44	356,113	70,343
23 00	−22 59	150 71	392,608	60,149*
March 5				
00 00	−22 61	135 74	399,796	60,624
06 00	−22 68	45 89	442,117	79,376
12 00	−22 72	315 95	483,204	113,528
18 00	−22 74	225 97	523,322	153,434
March 6				
00 00	−22 75	135 95	562,660	195,942
06 00	−22 76	45 90	601,348	239,979
12 00	−22 77	315 83	639,476	285,112
18 00	−22 77	225 75	677,116	331,132

* Nearest approach to the Moon (approx)

Discussion and Interpretation

The most striking features of Fig 4 are the immensely greater quantity of trapped radiation in the outer zone on March 3, 1959, than on December 6, 1958, and the detailed structure present, especially in the 60,000–90,000 km region It may also be noted that the observations by Vernov *et al*[2] with the Soviet cosmic rocket show that the situation on January 2, 1959, was similar to that on December 6 and 7, 1958 It is very suggestive that there was a substantial magnetic storm commencing at 02 15 U T on February 25 and that there were auroræ of strong intensity on February 25–28 and on March 1[3] A special study of this event by Trotter[4], of the High Altitude Observatory, makes it appear likely that at least three sequences of geophysical events starting on February 25, March 26 and April 23, respectively, were due to a solar *M* region In any event, it is noteworthy that the flight of *Pioneer IV* was preceded by five consecutive nights of strong auroral activity, whereas the periods preceding the flights of *Pioneer III* and of the Soviet cosmic rocket were especially

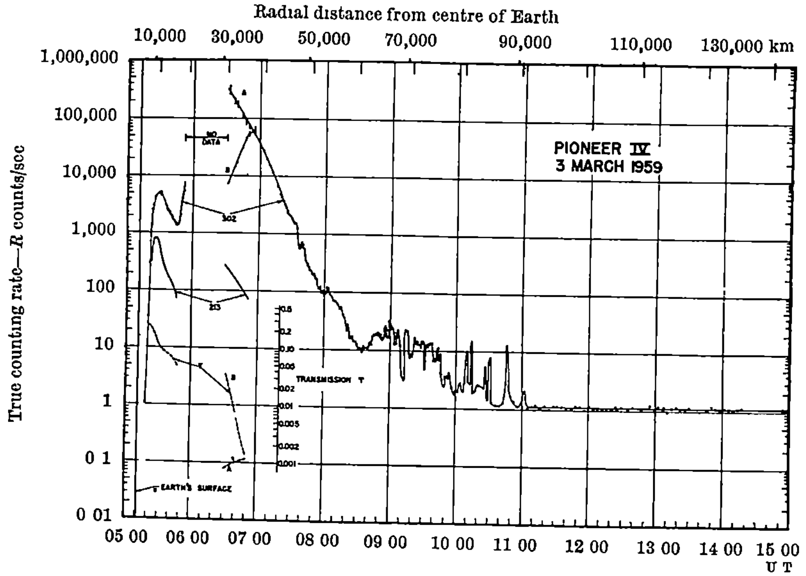

Fig 3 The counting rate observations during the early part of the flight of *Pioneer IV* (see text for further description of data)

quiet geophysical periods Hence we suggest that the great temporal differences shown in Fig 4 constitute the direct observation of the changes which occur in the outer radiation zone of trapped radiation following strong corpuscular emission from the Sun If this view be accepted then it appears that the *Pioneer IV* observations provide the most persuasive, direct evidence thus far available for the solar origin of (at least) the outer radiation zone

The inner peak of the *Pioneer IV* data (at 11,000 km) is about three times as intense as that of *Pioneer III* , but reference to Fig 2 and to a large-scale, corrected[5] plot as in Fig 5 of ref 1 shows that the inner zone was not significantly different on the occasions of the two flights From this fact it may be concluded that the inner zone, lying as it does in the region of strong geomagnetic field, is relatively well isolated from direct solar influence

The *A–B* ambiguity referred to in the preceding section in connexion with Fig 3 (and Fig 4) has not been conclusively resolved, but the following discussion strongly favours branch *A* as the correct one The work of Vernov *et al*[2] makes it appear likely that in the outer zone the effects recorded by a detector under more than 1 gm / cm^2 of absorber are due to bremsstrahlung from the bombardment of the outer skin of the payload by electrons of energies less than 100 keV and with a spectrum steeply rising toward lower energies If this be so, then we note that transmission curve *B* of Fig 3 not only has a quite unreasonable steepness but at its inner end has a value at least an order of magnitude greater than that measured in the laboratory with X-ray beams generated by electrons of such energies But transmission curve *A* is altogether consistent with this radiation situation

Adopting branch *A* and making use of our absolute X-ray calibrations of the 302 tube, we find that the omnidirectional flux of electrons of energy greater than about 20 keV was of the order of 1×10^{11}/cm^2 sec at 30,000 km radial distance on March 3, 1959

Also it is evident that the omnidirectional flux of electrons of energy greater than 200 keV did not exceed 1×10^8/cm^2 sec , of electrons of energy greater than 2 5 MeV did not exceed 1×10^6/cm^2 sec , and of protons of energy greater than 60 MeV did not exceed 1×10^2/cm^2 sec

The observations of *Pioneer IV* in the inner zone are unambiguous and show that about 30 per cent of the radiation recorded by the 302 in the lower fringe of the zone also penetrates an additional 4 0 gm /cm^2 of lead and 0 6 gm /cm^2 of steel The radiation becomes rapidly and progressively softer as one goes outwards from the Earth (Fig 3) On the basis of two recent rocket investigations into the lower fringe of the inner zone[6,7] and of our extensive *Explorer IV* and *Pioneer III* observations[1,8], we propose the following tentative composition of the trapped radiation present in the heart of the inner zone (altitude about 3,600 km on the geomagnetic equator) (*a*) electrons of energy greater than 20 keV —maximum unidirectional intensity $\sim 2 \times 10^9$/cm^2 sec steradian, (*b*) electrons of energy greater than 600 keV —maximum unidirectional intensity $\sim 1 \times 10^7$/cm^2 sec steradian , (*c*) protons of energy greater than 40 MeV —omnidirectional intensity $\sim 2 \times 10^4$/cm^2 sec The

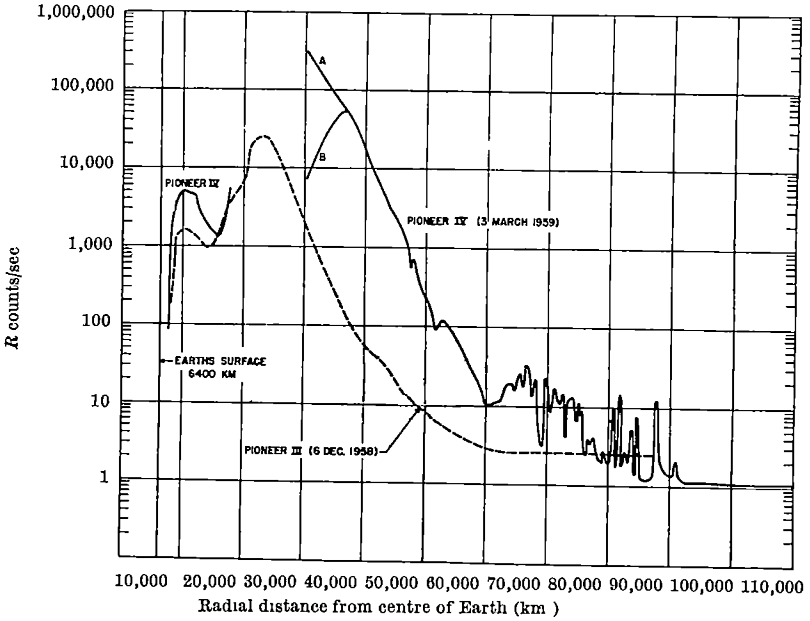

Fig 4 A comparative plot of the intensity data of *Pioneer III* and *Pioneer IV* on the same scale of radial distance but ignoring differences of latitude and longitude

latter two of these three figures are probably trustworthy to a factor of 2, the first one to a factor of 5 These results favour the neutron albedo hypothesis of origin of the inner zone of Vernov and others (cf discussion of ref 8), in respect to both the electron and proton components A valuable discussion of the proton component has been given recently by Hess[9] Some residual doubt may be felt as to the adequacy of the source function It should also be noted that there is a rapidly developing body of knowledge on the sporadic, though relatively frequent (order of once a month) arrival of solar protons having energies up to several hundreds of MeV and intensities up to several orders of magnitude greater than that in the quiet cosmic ray beam[10-13]

The conclusive identification of protons in the lower fringe of the inner zone[7] and the resemblance of their spectrum there to that expected on the neutron albedo hypothesis[9] has been accepted by many workers as conclusive evidence for the adequacy of this hypothesis The quantitative considerations of Hess have also added strongly to this point of view But it should be remarked that others, including Morrison, Gold and the present authors[8], have some uneasiness in accepting a trapping-lifetime of several years, as is necessary for the success of the neutron albedo hypothesis Thus, it is comforting to find that there is now an alternative source of protons (that is, direct solar emission) of suitable energy and intensity, provided a valid mechanism can be discovered for their admission into the inner zone The reader is also cautioned to await observations during the oncoming period of minimum solar activity for illuminating evidence on temporal changes in both inner and outer radiation zones Such a programme of observation is being undertaken by this laboratory

Radiation Intensity Beyond 92,000 km

Pioneer IV provided a total of 45 hr of observation of the counting rate of the 302 Geiger tube in the range of 92,000–658,300 km from the centre of the Earth (The counting-rate-meter circuit of the 213 was not sufficiently sensitive to provide a reading at any time during this portion of the flight) The mean counting rate was calculated over each interval of time during which 256 (2^8) counts were recorded The distribution of counting rates in the 695 such intervals (each of about 4 min duration) has been studied in detail and it has been found that during no one of these intervals did the counting rate differ with statistical significance from the overall mean value of 1 090 ± 0 003 counts per sec

A broader scale survey of the mean counting rate during larger segments of the trajectory was obtained by tabulating the times at which 'flips' of the major scaler ($2^{13} = 8{,}192$ counts per major 'flip cycle') occurred The constancy of the counting rate during observed periods encouraged us to also 'count through' the unobserved periods of time, during which the payload was below the effective horizons of the receiving stations During the longest such period six major flips were missed, and during the other two such periods four major flips were missed if it be assumed that the counting rate did not differ markedly when under observation and when not under observation The results of this process are shown in Table 2 The trustworthiness of the tabulated counting rates during unobserved periods rests on *a posteriori* evidence as follows On the assumption that the unobserved counting rates did not differ markedly from the observed ones, it is found in Table 2 that the unobserved counting rates differed by less than 1 per cent (that is, to within statistical uncertainty) from the adjacent, observed ones The precision of this agreement in all three of the cases under consideration gives one a strong feeling of assurance that the counting rate of the 302 did not differ significantly at any time in the interval 92,000 to 658,000 km (March 3, 11 10 U T, to March 6, 15 00 U T) from its mean observed value of 1 090 ± 0 003 counts per sec Several valuable conclusions follow from this analysis and are described in subsequent sections

Table 2 SUMMARY OF DATA FROM 302 TUBE BEYOND 92,000 KM BY FLIPS OF MAJOR SCALER
(8,192 counts per flip cycle)

Serial No of flip	Time of flip and station, day, hr, min, sec	Δt sec	Mean counting rate (sec)$^{-1}$	Radial distance to centre of Earth (km)	Radial distance to centre of Moon (km)
0	3/12 18 19 *JB*				
0	3/12 18 22 *PR*				
1	3/14 23 13 *PR*	7,491	1 094±0 012		
0	3/12 18 22 *GL*			104,920	276,240
1	3/14 23 10 *GL*	7,488	1 094±0 012	126,740	257,130
2	3/16 29 18 *GL*	7,568	1 082±0 012	147,440	239,080
3	3/18 34 18 *GL*	7,500	1 092±0 012	167,020	222,150
4	3/20 39 15 *GL*	7,497	1 093±0 012	185,880	205,940
5	Not observed	52,620	1 090±0 005		
6	Not observed				
7	Not observed				
8	Not observed				
9	Not observed				
10	Not observed				
11	4/11 16 15 *JB*			305,450	104,890
12	4/13 20 55 *GL*	7,480	1 095±0 012	321,340	92,750
13	4/15 27 07 *GL*	7,572	1 082±0 012	337,150	81,630
14	4/17 33 18 *GL*	7,571	1 082±0 012	350,930	73,140
15	4/19 38 40 *GL*	7,522	1 089±0 012	366,420	65,620
16	Not observed				
17	Not observed	37,386	1 096±0 005		
18	Not observed				
19	Not observed				
20	5/06 01 46 *JB*			440,610	79,340
21	5/08 06 13 *JB*	7,467	1 097±0 012	454,910	88,910
22	5/10 12 23 *JB*	7,570	1 082±0 012	470,990	102,420
23	5/12 16 32 *JB*	7,449	1 100±0 012	485,110	115,320
24	5/14 22 33 *GL*	7,561	1 083±0 012	499,230	128,950
25	5/16 27 21 *GL*	7,448	1 100±0 012	513,040	142,810
26	5/18 30 55 *GL*	7,414	1 105±0 012	525,090	155,280
27	5/20 35 15 *GL*	7,460	1 098±0 012	540,350	171,510
28	Not observed				
29	Not observed	37,620	1 089±0 005		
30	Not observed				
31	Not observed				
32	6/07 02 15 *JB*			607,950	247,650
33	6/09 08 41 *JB*	7,586	1 080±0 012	619,840	261,660
34	6/11 13 48 *JB*	7,507	1 090±0 012	634,630	279,290
35	6/13 20 57 *GL*	7,629	1 074±0 012	647,990	295,390

Overall mean for 35 intervals, 1 090 ± 0 002 counts/sec
Overall mean for 17 observed intervals, 1 090 ± 0 003 counts/sec
PR, Puerto Rico, *GL*, Goldstone Lake, *JB*, Jodrell Bank

Paucity of Energetic Plasma in Interplanetary Space during March 3-6, 1959

On the basis of Table 2 and the foregoing discussion, it appears that, to high accuracy, the apparatus did not encounter any solar plasma containing particles sufficiently energetic to register efficiently on the 302 tube during some 76 hr of interplanetary flight

Since the burden of evidence for the origin of the outer radiation zone of the Earth requires that plasma fly outwards from the Sun sporadically, it must be concluded that there happened to be a notable absence of such plasma during this period This finding is especially striking in view of the strong geophysical activity during the preceding week An alternative view is that the acceleration of the components of the plasma to sufficiently high energies to be registered efficiently by our equipment occurs only in the geomagnetic field. The 302 tube in the present arrangement had an efficiency of about unity for protons of energy greater than 30 MeV., an efficiency of the order of unity for electrons of several MeV. energy, and an efficiency of the order of 10^{-4} to 10^{-6} for electrons in the hundreds to tens of keV. energy-range (by way of their bremsstrahlung).

Hence, during the 76 hr. in question the time-integrated flux of the higher-energy electrons and protons could not have exceeded 100/cm.^{2} in an isolated burst during any one of the 695 observed 4-min. intervals, could not have exceeded 1,000/cm.^{2} in an isolated burst during any one of the three unobserved periods which had a duration of some 10 hr. each, and could not have exceeded 2×10^5/cm.^{2} if distributed (with quite unbelievable uniformity) over the 76-hr. period. The corresponding figures for 60 keV. electrons, for example, are 4×10^5 times as great.

Lack of Influence of the Moon

Pioneer IV's closest approach to the centre of the Moon was 60,149 km. at about 23.00 U.T. on March 4 (Table 1). The telemetered signal was not being received at that time (see section on "Telemetry" and Table 1). But observations were obtained as close as 61,700 km., and Table 2 and the accompanying discussion make it exceedingly unlikely that any significant change of counting rate occurred at any place in the vicinity of the Moon. The quantitative discussion of the preceding section is applicable here also. The geometrical shadow of the Moon on the apparatus was, of course, negligible. Hence, this result suggests as an upper limit to the Moon's magnetic moment a value comparable to that of the Earth. This high an upper limit is, of course, of little interest in the light of other, probably more definitive, knowledge which favours a much smaller value.

The Soviet cosmic rocket passed much closer to the Moon than did *Pioneer IV*, but unhappily the radiation intensity was unreadable at that range.

None the less, the determination of the Moon's magnetic moment by investigating its trapped corpuscular radiation on near approaches remains a technique of potential value. It will doubtless be wise to use a detector of the lowest feasible energy threshold and of the highest feasible sensitivity.

Re-determination of Interplanetary Cosmic-ray Intensity

On the basis of Table 2 and of our best present values of absolute geometric factor and efficiency of the 302 Geiger tube, we find for the interplanetary value of the omnidirectional cosmic-ray intensity $J_0 = 1.8 \pm 0.3$/cm.^{2} sec. during the period March 3–6, 1959.

It may be noted that this value is one-half of that measured[1] on December 6 and 7, 1958, with *Pioneer III*. On the basis of a recent re-study of *Pioneer III* data, Snyder[14] presents evidence that *Pioneer III* did not reach a sufficiently great distance to be entirely free of the influence of the geomagnetic field.

The *Pioneer IV* observations to very much greater distances (out to 103 Earth radii) are not subject to this uncertainty. Hence, we have considerably greater confidence in the new value quoted above, though it should be understood that the counter will record protons of energy as low as 30 MeV. and electrons of energy as low as 2.2 MeV. In any event, the measurement provides a solid upper limit to the total primary cosmic-ray intensity in the general astronomical vicinity of the Earth during early March 1959.

Using balloon-borne equipment of discriminating character, McDonald[15] finds primary unidirectional cosmic-ray intensities (corrected to zero atmospheric depth) at geomagnetic latitude 55° on July 2, 1958, as follows:

(*a*) Protons of energy greater than 280 MeV. 0.0950 ± 0.0070/cm.^{2} sec. steradian

(*b*) α-Particles of energy greater than 158 MeV./nucleon 0.0149 ± 0.0012

(*c*) Sum of (*a*) and (*b*) 0.1099

An interesting comparison results from multiplying McDonald's sum of 0.11/cm.^{2} sec. steradian by 4π to obtain an estimate of the omnidirectional intensity of primary cosmic rays remote from the Earth. The result is $J_0 = 1.38$/cm.^{2} sec. In so far as McDonald has been able to eliminate fast, downward-moving albedo, his implied J_0 has the nature of a lower limit.

Vernov and Chudakov[2] report a value of 2.3 ± 0.1/cm.^{2} sec. on January 2, 1959.

Effective Extent of the Geomagnetic Field

Our original interpretation of the *Pioneer III* observations[1] included the conclusion that the geomagnetic field loses its ability to trap charged particles at about 10 Earth radii. Snyder's discussion makes it appear that this was too small a value. The *Pioneer IV* observations (Fig. 4) indicate that geomagnetic trapping is significantly present out to as far as 14 Earth radii, at least on a specific occasion. The loss of geomagnetic trapping efficiency is, of course, a loosely defined concept and there are doubtless marked fluctuations in the radiation regions at the outer fringes of the Earth's field.

Terrestrial Ring Current of Dolginov and Pushkov

Measurement of the scalar magnetic field intensity with the magnetometer in the Soviet cosmic rocket on January 2, 1959, provided results of very great interest[16] in the present connexion. The observed scalar field intensity fell gradually and progressively farther below the curve representing the extrapolation of the surface field (using an eight-coefficient harmonic expansion and assuming a curl-free field outside the solid Earth) in the radial distance range 14,000–21,000 km. At 21,000 km., the experimental curve was some 700 gammas below the 'theoretical curve' (about 1,200 gammas). At greater radial distances the experimental curve rose toward the theoretical one and approximated to it beyond 26,000 km. These results imply a westward-flowing ring current having the maximum value of the apparent current density at about 21,000 km. radial distance from the centre of the Earth. By comparison with Fig. 4 of the present article, it is seen that the most intense portion of the ring current lies in the inner side of our outer peak of radiation intensity and indeed in just the region in which the gradient of the volume density of charged-particle kinetic energy has its greatest value. The understanding of the detailed relationship between the Dolginov–Pushkov ring current and the trapped radiation now becomes one of the most challenging and timely problems of geophysics[17].

It may be speculated that the modification of the geomagnetic field by the ring current at about 3 Earth radii influences the structure of the radiation zones and perhaps contributes to the existence of the 'slot' between the two zones.

We are indebted to Dr. William H. Pickering, director of the Jet Propulsion Laboratory, for the opportunity to conduct the present work and for financial support, and to Messrs. Henry Curtis, Dan Schneiderman, John Casani, and Frederick Smith and Dr. Conway Snyder, all of Jet Propulsion Laboratory, for many courtesies during the course of the work.

Overall management of the programme rested with the National Aeronautics and Space Administration.

[1] Van Allen, J. A., and Frank, L. A., *Nature*, **183**, 430 (1959).
[2] Vernov, S. N., Chudakov, A. Ye., Vakulov, P. V., and Logachev, Yu. I., *Doklady Akademia Nauk S.S.S.R.*, **125**, 304 (1959).
[3] Billings, Prescott and Dolder, Preliminary Report of Solar Activity, *TR* 392 of March 6, 1959, High Altitude Observatory, Boulder, Colorado.
[4] Trotter, Dorothy E., "Solar Activity preceding the Geomagnetic Storms of 25 February and 26 March, 1959" (private communication).
[5] The trajectory of *Pioneer III* in Fig. 5 of ref. 1 was mistakenly not converted to geomagnetic co-ordinates. The corrected version of Fig. 5 differs only slightly from the one published, however.
[6] Holly, F. E., and Johnson, R. G., "Composition of Radiation Trapped in the Geomagnetic Field at Altitudes up to 1,000 kilometers" (private communication, May 1959).
[7] Freden, S. C., and White, R. S., *Phys. Rev.*, Letters, **3**, 9 (1959).
[8] Van Allen, J. A., McIlwain, C. E., and Ludwig, G. H., *J. Geophys. Res.*, **64**, 271 (1959).
[9] Hess, W. N., *Phys. Rev.*, Letters, **3**, 11 (1959).
[10] Anderson, K. A., *Phys. Rev.*, Letters, **1**, 335 (1958).
[11] Leinbach, H., and Reid, G. C., *Phys. Rev.*, Letters, **2**, 61 (1959).
[12] Anderson, K. A., Arnoldy, R., Hoffman, R., Peterson, L., and Winckler, J. R., *J. Geophys. Res.* (in the press).
[13] Rothwell, P., and McIlwain, C. E., *Nature*, **184**, 138 (1959).
[14] Snyder, C. W., *Nature* (in the press).
[15] McDonald, F. B., *Phys. Rev.* (in the press).
[16] Dolginov, S., and Pushkov, N., International Conference of Cosmic Ray Commission of I.U.P.A.P., July 6–11, 1959, Moscow. See also *Pravda* of July 15, 1959.
[17] Cf. Chapman, S., and Bartels, J., "Geomagnetism", **2**, 710, 850 (Clarendon Press, Oxford, 1940).

RADIOCARBON DATING OF THE PILTDOWN SKULL AND JAW

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and

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Introduction
(K. P. Oakley)

In 1950 it was shown[1] by the fluorine method of relative dating that the Piltdown mandible and cranial bones were considerably younger geologically than the Lower and Middle Pleistocene fossils said to have been found at the same site. Assuming that they were genuine finds, the hominoid remains were not older than Upper Pleistocene, but it was noted that drill-holes into the teeth revealed that they were "apparently no more altered than the dentine of recent teeth from the soil"[2]. In 1953, Dr. J. S. Weiner, reviewing this evidence in the light of anatomical considerations, suggested that the mandible was that of a recent ape which had been broken and stained to resemble a fossil, and the teeth artificially abraded to suggest wear through the human type of mastication. According to his hypothesis, the fraudulent jaw-bone had been placed in the Piltdown gravel pit so as to appear associated with fragments of a thick human cranium of presumed antiquity.

Determination of the organic content and re-determination of the fluorine content of these specimens, together with evidence obtained from a detailed anatomical analysis of the teeth, confirmed this hypothesis[3] (Table 1). The mandible had the composition of modern bone, whereas the cranial fragments were very slightly 'fossilized'.

In 1953–55, the possibility of dating the Piltdown bones absolutely by the radiocarbon method was not seriously considered because it would have involved total destruction of the specimens to provide the minimum quantity of carbon (2 gm.) then demanded by radiocarbon laboratories for a single determination. During the past four years, improvement of technique has made it possible to attempt radiocarbon dating on the basis of much smaller quantities. With the agreement of Dr. E. I. White, keeper of palæontology, powder samples of the Piltdown mandible and right parietal bone were submitted to Prof. H. de Vries after repeated washing in acetone and then in warm water (at 70° C.) which was carried out under rigorous conditions in the Department of the Government Chemist. The nitrogen content of powder samples of these bones proved to be the same before and after submission to this extraction treatment, proving their freedom from nitrogenous contaminants (for example, glue, gelatine, celluloid). Their nitrogen content represents the *bone protein* (collagen), which is not removable by acetone or warm water. This is the material which provided the carbon the radioactivity of which has now been measured.

Table 1

	Fluorine (per cent) (1950)	Fluorine (per cent) (1953)	Nitrogen (per cent)	Carbon (per cent)
Piltdown mandible	0·2 ± 0·2	<0·03	3·9	14·5
Piltdown cranium	0·2 ± 0·1	0·10 ± 0·01	1·4	5·3
Fresh bone		0·03 ± 0·01	4·0	14·0

The Radiocarbon Results
(H. de Vries)

The sample of Piltdown mandible was burnt without any further pretreatment. The sample of the Piltdown skull (right parietal) was given a treatment which will be described in more detail elsewhere. It was dissolved in hydrochloric acid; the fraction which was not precipitated by alkali was dated. Both samples gave a very small amount of carbon dioxide, corresponding to about 0·1 gm. of carbon. Therefore, the precision is not what it could have been, but certainly good enough for the present purpose. Though controversial dates on bone have been published, our recent experience indicates that the conclusions drawn from the present results are trustworthy (Table 2).

Table 2

Piltdown mandible (*GRO* 2204)	500 ± 100 years*
Piltdown skull (*GRO* 2203)	620 ± 100 years*

Expressed in terms of statistical probability, there is 1 chance in 3 that the ages of these specimens lie outside the stated limits, but only 1 chance in 20 that they lie outside the ranges 500 ± 200 and 620 ± 200 years, respectively.

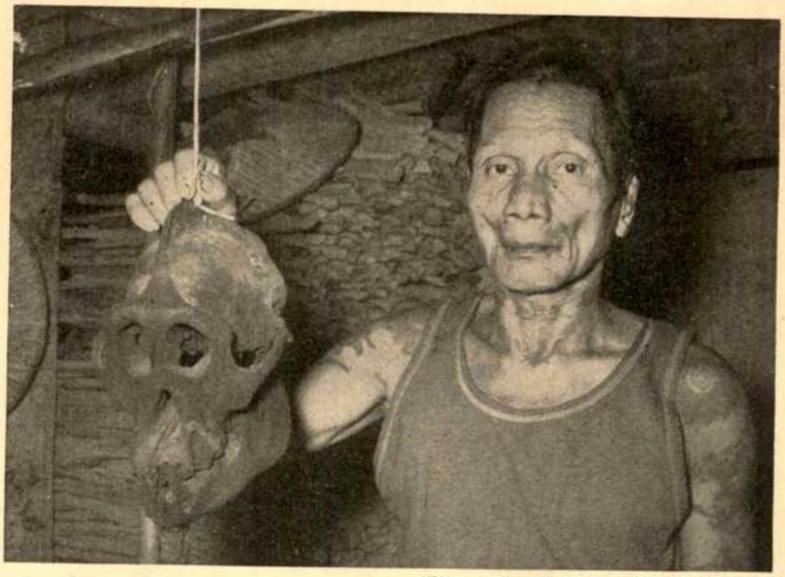
* Allowance has been made for the Suess effect (that is, the age was calibrated against nineteenth-century wood).

Comments on the Results
(K. P. Oakley)

The results are satisfactory. In the first place they confirm that the Piltdown jaw is geologically quite recent. (Even since the exposure of the hoax in 1953 and 1955, statements have appeared in print maintaining that it is a Pleistocene fossil, considerably more ancient than the cranial bones.) The indication that this mandible is a few centuries old raises the question of its origin. When Sir Wilfrid Le Gros Clark established that it was the jaw-bone of a modern orang-utan (and therefore came from Borneo or Sumatra), it was assumed to be a zoological collector's piece. Is it not very unlikely that an orang-utan jaw-bone falling into the hands of a collector would prove to be several centuries old ? In fact, this is not so improbable as might be supposed. One possibility is that the specimen was obtained from a dealer in ethnographical material. Prof. G. H. R. von Koenigswald has pointed out that the Dyaks of Borneo have been known to keep orang-utan skulls as fetishes or trophies[4] in their long-houses for many generations. Mr. Tom Harrisson, curator of the Sarawak Museum, recently sent to the British Museum (Natural History) a photograph of an orang-utan skull, with mandible, which is said to have been preserved for twenty generations—about 400 years (Fig. 1). However, the chances of an ethnographical dealer obtaining such a highly treasured object directly from living Dyaks are regarded by Mr. Harrisson as negligible. On the other hand, he has pointed out that a number of sub-recent bones of orang-utan, obtained in Sarawak in various circumstances, were brought back to Britain in 1875 by A. H. Everett and briefly described[5]. Some were obtained from caves the contents of which were washed by Chinese gold workers. At least one of the specimens (No. 55) appears to have been a trophy skull. Part of Everett's collection (including the last specimen) was presented to the British Museum (Natural History). All the orang-utan skulls and jaws listed as received by the Museum in 1879 can be accounted for ; but Mr. Harrisson believes that Everett brought much more material to Britain, and what became of it is unknown. Did it pass into the hands of dealers ?

Comparison between one of the 'sub-recent' orang-utan jaw-bones in the Everett Collection (No. 100 in Everett's list, recorded as "doubtfully from a cave" in Sarawak ; registered as *ZD*.84.10.30.2) and the Piltdown jaw-bone has brought out a number of points of resemblance. Not only is the nitrogen content of the 'antique' Bornean specimen likewise undiminished (4·6 per cent, determined by Mr. G. Ross in the Central Laboratory, Department of Zoology, British Museum (Natural History) ; he has reported 4·0–5·3 per cent nitrogen in other recent Hominoid bones) but also the surface of the bone is in the same finely cracked condition, which was difficult to account for if the Piltdown specimen came from a modern zoological collection. Attempts to reproduce the appearance of the Piltdown jaw by artificial treatment of modern bones failed in just this respect. The condition of the collagen fibres, revealed by the electron-microscope, indicated that it had *not* been boiled.

The radiocarbon dating of the cranial bones has confirmed that they also are Post-Pleistocene in age as indicated in the report of 1955 (p. 257). In 1953, it was thought that they might have been genuine finds which had served as the nucleus of the hoax ; but as soon as it was proved (as reported by Dr. G. F. Claringbull and Dr. M. H. Hey in 1955) that all the cranial fragments had been artificially stained to match the gravel, it became clear that they were fraudulent introductions at the site, so the possibility of their being of Pleistocene age could be entirely discounted. The phosphatic matter of these cranial bones has been partially altered to gypsum. This is only explicable if they had been artificially stained by an acid iron sulphate solution. Experiments showed that this alteration only occurs if the bone has the porosity due to partial loss of organic matrix. Thus the Piltdown cranial bones are evidently of moderate antiquity. Presumably they were fragments of a skull selected on account of its unusual thickness from among a series obtained in the excavation of some ancient burial ground. The fluorine content of the unaltered portion of their bone substance also indicates that they are of some slight antiquity ; but unless one knows the source of a bone, precise relative dating by fluorine content is impossible. However, in many British and foreign cemeteries bones less than a thousand years old can be found with the same fluorine content (0·1 per cent).



(*Photo : Tom Harrisson, Sarawak Museum*)

Fig. 1. Orang-utan skull with mandible kept as a fetish in a Dyak long-house seventy miles from Kuching and said to be twenty generations (about 400 years) old

Although the difference in the radiocarbon ages of the cranial bones and mandible is less than might have been expected in view of their contrasting states of preservation, it should be borne in mind that whereas a bone that has been buried in the ground for a few centuries may have become porous and 'sub-fossil' (with some absorbed fluorine), a bone of equal antiquity that has been preserved in air, for example on the floor of a dry cave, in a building or in a reliquary, may have retained the composition of 'recent' bone.

Summary. Radiocarbon dating has confirmed that the Piltdown skull (human) is Post-Pleistocene, probably less than 800 years old; and that the Piltdown mandible (orang-utan) is younger rather than older, although possibly several centuries old. It is shown that these findings are not inconsistent with the skull being in 'sub-fossil' condition whereas the mandible (of very different origin) has the preservation of 'recent' bone.

[1] Oakley, K. P., and Hoskins, C. R., *Nature*, **165**, 379 (1950).

[2] Oakley, K. P., and Hoskins. C. R., *Nature*, **165**, 381 (1950).

[3] Weiner, J. S., Oakley, K. P., and Le Gros Clark, W. E., *Bull. Brit. Mus.* (*Nat. Hist.*), *Geol.*, **2**, No. 3, 139 (1953), reporting nitrogen determinations by Mrs. A. Foster in the Brit. Mus. (Nat. Hist.) Dept. of Minerals, and fluorine determinations by Mr. C. F. M. Fryd in the Dept. of the Government Chemist. Fuller account in *Bull. Brit. Mus.* (*Nat. Hist.*), *Geol.*, **2**, No. 6, 225 (1955).

[4] See, for example, Martin, R., "Über Skeletkult und verwandte Vorstellungen", *Mit. Geogr. Ethnogr. Gesell.. Zürich* 1920, Taf. 4, Fig. 6.

[5] Everett, A. H., Second Quarterly Report on the Bornean Cave Exploration, Rep. Brit. Assoc., Sheffield, 144 (1879).

DISORGANIZATION OF THE SECONDARY STRUCTURE IN PROTEINS EXPOSED TO IONIZING RADIATIONS IN THE SOLID STATE

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LITTLE is known of the chemical and physical changes which occur when proteins are exposed to ionizing radiations under conditions where the effect is due to ionization within the protein molecules, that is, by 'direct' action. Detailed physical chemical studies have only been made on protein irradiated in solution when the reaction is indirect and due to free radicals. Most investigations of the direct effect have been confined to following the effect on their biological properties. It has been known for nearly fifteen years (cf. Lea[1]) that the inactivation of dry enzymes by ionizing radiations is exponential with dose, which suggests that one event leads to loss of activity. The amount of energy which has to be supplied before this single reaction occurs is normally between 50 and 200 eV. per molecule, depending on the enzyme. Quantitatively this suggests that nearly every primary ionization must be effective in destroying the biological activity. A primary ionization in an organic substance brings with it far-reaching chemical changes which usually affect several groups, but it seems highly improbable that the inactivation of all enzymes can be attributed to the chemical modification of a few amino-acid residues.

Biochemical studies[2] have shown that for many enzymes only a small part of the protein molecule is necessary, and that a large proportion of the amino-acid residues can be modified without loss of activity. Energy transfer processes which were recognized in organic macromolecules[3] cause preferential attack of some groups; but the effect is not sufficiently selective to provide a mechanism for the inactivation of all enzymes by a single random event.

In a detailed study of the changes produced by irradiating solid crystalline bovine serum albumin (Armour Laboratories) containing 4–6 per cent of water with 2 MeV. electrons, in the absence of oxygen we have found that the first effect of irradiation is to disorganize a large part of the molecule. This alteration in structure is not dependent on covalent chemical changes which follow ionization, but is the result of a breakdown of many secondary valency bonds brought about by a single event which occurs on average for every 45 eV. deposited and can therefore be associated with a primary ionization. The occurrence of a process of this type was predicted by Platzman and Franck and provides a mechanism for the inactivation of heat-labile enzymes of all types by ionizing radiations.

Opening up the Molecule

On irradiation the sedimentation behaviour of the bovine serum albumin in the ultracentrifuge changes[4], and the decrease in normally sedimenting material follows an exponential relationship (Fig. 1), with a Do (dose required to change 63 per cent of all molecules) of $6\cdot5 \times 10^6$ rads. This corresponds to an energy of 45 eV. per molecule, which has to be supplied to affect on average one molecule. Change in sedimentation implies an alteration in molecular weight or in frictional resistance determined by the internal structure of the molecule. Light-scattering measurements show that with a dose sufficient to alter the sedimentation of 75 per cent of the molecules, the average molecular weight of bovine serum albumin rises only from 69,000 to 90,000. The ultracentrifuge measurements therefore indicate that a single event which occurs on average for every 45 eV. of energy supplied changes the shape of the molecule. The assumption that the material sedimenting normally is native protein that has not been affected at all by radiation is confirmed by chromatography.

Evidence that radiation 'opens up' the molecule is provided by changes in the chemical reactivity of the constituent amino-acid residues. Bovine serum albumin contains seventeen disulphide groups per molecule, but at the isoelectric point none of these can be reduced to $-SH$ groups[5], or oxidized with peracetic acid to sulphonic acid groups[6] under standard conditions. These groups are sterically inaccessible, but at pH values away from the isoelectric

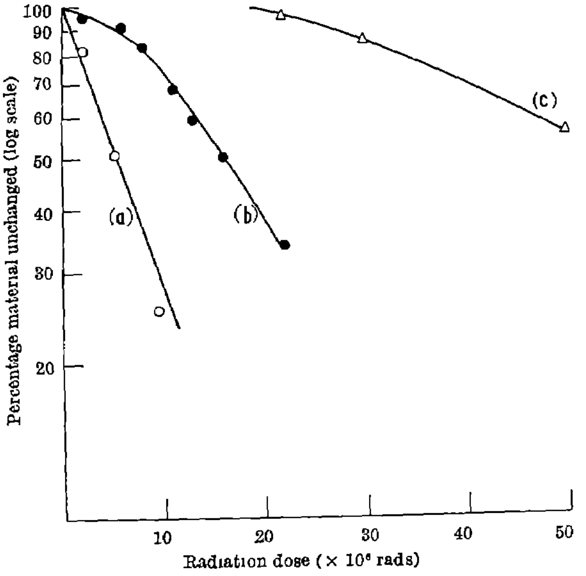

Fig 1 Effect of irradiation of 2 MeV electrons on some physical properties of bovine serum albumin

a, Fraction of bovine serum albumin showing changed sedimentation behaviour in the ultracentrifuge, *b*, fraction of bovine serum albumin insoluble in water, *c*, fraction of bovine serum albumin insoluble in *M*/15 phosphate buffer (*p*H 7)

point, or following denaturation, some become available for reaction Exposure to 4 *M* guanidine hydrochloride at the isoelectric point makes available 70 per cent of the total present, and this is further increased at alkaline *p*H values On the other hand, a maximum of only 50 per cent are revealed by heat denaturation[6]

Irradiation of the solid protein progressively increases the number of disulphide bonds available up to a maximum of 50 per cent (Fig 2) (at the highest doses some of these are destroyed, but within the dose-range studied this is negligible) From the irradiated bovine serum albumin a fraction can be separated which is no longer soluble in water, and dissolves only in salt solution In the water-soluble fraction an increasing proportion of the disulphide bonds (up to 30 per cent) is revealed, and by applying a correction, on the basis of the ultracentrifuge measurements, for the presence of unchanged native material, the number of available groups in the molecules affected by radiation can be calculated (Fig 2) This first radiation change can be described as an opening up of the molecule which changes the frictional properties but not the molecular weight, and reveals five disulphide bonds normally hidden Since this change is associated with a single reaction which occurs when an average of 45 eV have been left in the molecule, it can probably be ascribed to the production of one primary ionization

Changes following a Multi-Hit Dose Relationship

Another radiation effect is to render the protein insoluble in water, while remaining soluble at high and low *p*H values and in salt solutions To avoid 'trapping', the insoluble fraction is determined by measuring the protein which comes out of solution on dialysing out the *M*/15 phosphate buffer (*p*H 7) in which the irradiated protein is completely soluble Fig 1 shows that in the production of insolubility there is a pronounced threshold with dose, and it fits accurately a 'two-hit' curve This protein has a greatly increased light-scattering molecular weight with average values ranging up to 350,000, but is highly poly-disperse. These aggregates are not broken up, that is, the average molecular weight is unchanged, by solvents breaking hydrogen bonds or disulphide bonds, and the cross-links joining the molecules in the aggregates do not therefore involve either of these bonds An interpretation consistent with all the facts is that a second ionization still further disorientates the secondary structure of the molecule and thereby changes its solubility behaviour, enabling cross-links to be formed between molecules In this extensively modified protein following the second ionization approximately half the disulphide bonds are available

Further irradiation does not reveal any more disulphide bonds, but it does render the protein insoluble even in salt solution (curve *C*, Fig 1). This heavily irradiated material dissolves only in 4 *M* guanidine hydrochloride Probably extensive chemical alterations now involving about 5 per cent of all the amino-acid residues made extensive intermolecular hydrogen bonding possible

Chemical Changes

Chemical analysis of the irradiated protein for nine amino-acids shows that the disappearance of amino-acids (the nature of the products was not established) was linear with dose, but that the sensitivity of the constituent amino-acids varies Cystine and dicarboxylic acids were the most sensitive , the aromatic and the basic amino-acids came next in sensitivity and proline was the least affected by radiation of those studied However, the total range was less than a factor of three, for example, 10^8 rads affected 18 per cent of the cystine, 12 5 per cent of the histidine and 8 per cent of the proline Thus, after a dose sufficient (that is, 45 eV /molecule) to 'open up' the protein, only one molecule in five will have a single cystine residue changed, one in six one histidine residue, and only one in two will have lost a carboxyl group

The possibility that main-chain polypeptide bonds are broken was tested by looking for low molecular

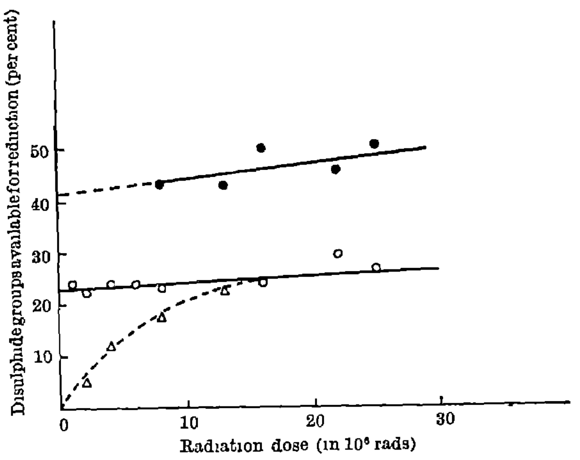

Fig 2 Effect of radiation on the number of disulphide bonds in bovine serum albumin which can be reduced at the isoelectric point with β-mercapto-ethylamine

—△—, For water-soluble fractions (that is, including the molecules that have not been affected by radiation), —○—, for water-soluble fraction after correction for unchanged protein on the basis of the ultracentrifuge data, —●—, for fraction insoluble in water, but soluble in salt solution weight fragments which could be recovered by dialysis of solution of heavily irradiated protein in 4 M guanidine hydrochloride. To guard against the possibility that broken fragments do not become detached because they are linked to the main molecule by disulphide bridges, the irradiated protein dissolved in guanidine hydrochloride was oxidized with peracetic acid, which breaks all disulphide bonds under these conditions. As no dialysable fragment could be found even after a dose of 2.5×10^8 rads it can be concluded that main-chain breaks play no part in the disorganization of the secondary structure.

Other chemical changes due to irradiation are the formation of carbonyl groups[7] and of additional SH groups, as well as of a new amino-acid which has the same chromatographic behaviour as α-amino-*n*-butyric acid.

The presence of oxygen during the irradiations did not alter the first stage of 'opening up' or the destruction of amino-acids. However, the protein is rendered insoluble in water at lower doses and the greater radiation sensitivity of dry enzymes in oxygen[8] may be due to the increased tendency for aggregation, or the production of main-chain breaks, which is facilitated by oxygen.

Mechanism of Enzyme Inactivation

Although bovine serum albumin has been studied by us in greatest detail, irradiation of solid trypsin, lysosyme and γ-globulin produces a very similar sequence of events, and we believe that the pattern outlined above applies generally to globular proteins. We interpret the changes which occur in a protein molecule by an ionization produced within it by an atomic particle as a two-stage process. First, the introduction of a positive charge disrupts the secondary structure over a large part of the molecule and introduces a new configuration. Secondly, the group in the molecule that has become ionized undergoes a chemical change. The latter are not randomly distributed and energy transfer processes increase the probability of damage in certain amino-acid residues. But these effects are not very selective and there is no indication that one particular type of side-chain will be altered in every protein molecule that had suffered an ionization. This precludes the possibility that loss of activity can be due to these chemical effects, and it seems much more plausible to relate inactivation to the initial disturbance of secondary structure as this is an immediate consequence of the ionization. An explanation is provided why ionizing radiations are much more effective (on a dose basis) in inactivating enzyme[9] than ultra-violet light or the indirect action of ionizing radiation (that is, H and OH radicals). Both these processes attack the protein chemically and alter side-chains, but they cannot disorganize the secondary structure directly.

We suggested tentatively[10] that the sudden introduction of a positive charge breaks down induced dipoles and that the resulting temporary opening of hydrogen bonds allows the protein molecule to adopt a configuration having a lower free energy. The difficulty is to provide a mechanism by which the electric disturbance spreads over a significant part of the protein molecule. Platzman and Franck[11] were led from purely theoretical considerations to postulate that an ionization within a protein molecule changes the internal hydrogen bonding. They have discussed the probable range of the electrical disturbance in considerable detail and conclude that some fifteen to twenty hydrogen bonds can be severed in this way. Not enough is known of protein structure to predict whether the breakage of this number of hydrogen bonds is sufficient to produce the observed disorganization.

We wish to thank Mr. W. H. T. Davidson, of the Research Laboratories of Tube Investments, Ltd., for carrying out the irradiations, and Dr. D. Rosen for the ultracentrifugation.

This investigation has been supported by grants to the Chester Beatty Research Institute from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

[1] Lea, D. E., "Actions of Radiations on Living Cells" (Cambridge University Press, 1947).

[2] Smith, E. L., Hill, R. L., and Kimmel, J. R., Symposium on Protein Structure, ed. Neuberger, A. (Methuen and Co., Ltd., London, 1957).

[3] Alexander, P., and Charlesby, A., *Nature*, **173**, 578 (1954).

[4] Rosen, D., Brohult, S., and Alexander, P., *Arch. Biochem. Biophys.*, **70**, 266 (1957).

[5] Katchalsky, E., Benjamin, G. S., and Gross, V., *J. Amer. Chem. Soc.*, **79**, 4096 (1957).

[6] Alexander, P., and Hamilton, L. D. G., *Biochim. Biophys. Acta* (in the press).

[7] Jayco, M. E., and Garrison, W. M., Report of Radiation Laboratory, University of California. *UCRL* 3872 (1957).

[8] Alexander, P., *Rad. Res.*, **6**, 653 (1957).

[9] (*a*) Lea, D. E., *Brit. J. Radiol.*, Supp. 1, ed. Spear, F. G., 35 (1947). (*b*) Alexander, P., Int. Conf. Radiobiol., Stockholm, 1956, Proc. in "Adv. Radiobiol.", ed. Hevesy, 8 (Oliver and Boyd, Edinburgh, 1957).

[10] Alexander, P., and Hamilton, L. D. G., Annual Report of B.E.C.C., 35, 13 (1957). Fourth Int. Cong. of Biochem. Abstr. of Communications, 2-82, Vienna, 1958 (Pergamon Press, London).

[11] Platzman, R., and Franck, J., Symposium on Information Theory in Biology, ed. Yockey, H. P. (Pergamon Press, London, 1958).

ORIENTATION OF ANIMALS TO POLARIZED LIGHT

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WORK done or published during the past year concerning the orientation of animals—mainly arthropods—to the plane of polarization of light indicates the emergence of two different and, up to a point, contradictory approaches to these visual reactions. What may be called the orthodox view gradually developed since von Frisch's original discovery in 1948 of the ability of bees to orientate themselves with respect to the plane of polarization, has been ably summarized in a review article by Stockhammer[1]. He considers the various types of arthropod eyes to be analysers and, in particular, thinks that the analysing faculty is not situated in the dioptric parts but depends upon special arrangements of visual pigments in the receptor cells which, like a polarizing screen, would combine the properties of analysis and absorption

Quite different conclusions have been drawn by Baylor and Smith (*Apis*)[2], Bainbridge and Waterman (*Mysidium*)[3], Burdon-Jones and Charles (*Littorina*)[4], as well as by Kalmus (*Aedes*, *Drosophila*, *Thaumatomyia*)[5], who considered that the orientational behaviour of these various animals in the presence of polarized light might be explained either by purely external mechanisms, for example, by brightness patterns resulting from unequal scattering or reflexion from environmental objects, or by similarly unequal refraction from some faces of the dioptric apparatus, such as the surface of the eye Neither of these interpretations requires analysing arrangements in the receptors

The hypothesis that the rhabdomers of insect ommatidia are absorbing analysers is supported by the electro-physiological results and electron microscopical work quoted by Stockhammer[1] , it has been further strengthened by the beautiful electron micrographs of insect eyes by Fernández-Móran[6], confirming that each rhabdomer is built up of numerous rod-shaped or tubular units which are oriented in regular array with their long axes more or less at right angles to the long rhabdomer axis In an opposite pair of rhabdomers in any ommatidium the rods or tubules show a similar orientation, but in adjoining rhabdomers their orientation differs The orientation of the rods in the rhabdoms of neighbouring ommatidia may follow a regional pattern At the level of the basement membranes 7–9 single sheathed nerve fibres exist in every ommatidium, indicating that separate signals might originate and be transmitted from each rhabdomer Some of Móran's figures show indeed a striking similarity to the 'star' model of an ommatidium, which von Frisch proposed many years ago for its analysing properties , and provided it can be shown that the dichroitic visual pigment is incorporated into the rhabdomer pattern in a regular and orientated manner, a physical basis would seem to exist for the assumption that the rhabdomers of insect eyes are indeed analysers Thus equipped, the eyes of a bee should be able to distinguish between various areas in the blue sky which, during the daytime, are fairly characteristic in their degree of polarization and direction of the plane of polarization, and which, according to von Frisch's experiments, they learn to recognize , and navigating bees might use this information, rather as they use the position of the Sun when it is directly visible to them

A transversal arrangement of rod-shaped structures seems to be of wide occurrence in the rhabdomers of arthropods, and a similar organization, found in the visual elements of the squid *Loligo*[7], may occur in the molluscs But in the rods and cones of vertebrates, the orientation of the structures to which the visual pigments are presumably attached is quite different and unsuitable for the detection of the plane of polarization of light impinging in the physiological direction

Reactions to polarized light striking the rounded surface of some types of bulgy eyes at a skew angle can be expected to produce specific orientational effects in the absence of retinal analysers Castle (quoted by Stockhammer[1]) has shown that a primitive type of such orientation occurs even in the absence of eyes, for example in fungi : the cylindrical sporangiophores of Phycomyces growing upwards in a culture respond unequally to light of equal intensity but different planes of polarization If light from two such sources strikes a sporangiophore from opposite directions it will bend, showing that the horizontally polarized light has a stronger effect than the vertically polarized light provided that the former is not the weaker in intensity by more than 10–15 per cent In compound eyes, perception of polarization in oblique rays of light is only possible if the optical isolation of the individual ommatidia is not absolute, and if some light initially deviating from the ommatidial axis can produce visual effects Such a situation is admitted by Stockhammer (quoting Waterman) to exist in *Limulus*, but denied by him for *Drosophila*, *Cladocera* and *Mysidium* It may nevertheless occur in some commoner situations , for example, when insects fly under large areas of strongly polarized light from the sky bordering directly on dark areas in their visual field

Selective reflexion of polarized light by structures in the environment of an animal provides another means of orientation, by producing brightness patterns Such patterns being objective can be made visible to the human eye In Baylor and Smith's[2] experiments, bees were released into a flat chamber covered with clear glass and illuminated only by plane polarized light from above Those bees which crossed the box tended to run preferentially at right angles to the plane of polarization when the bottom of the chamber was covered with some dark and reflecting material, whereas over a white paper they did not show any directional preference Under unpolarized light, preferential directions of running were observed over a directionally biased dark reflecting surface Bees running under a source of polarized light over the dark bottom of the chamber showed orientation even when the light could not strike their eyes directly, regardless of whether they were running on the dark surface or upside down on the glass A periscope-like arrangement showed that the intensity of the light reflected at sighting angles of 10–30° from the dark surface under polarized light varied greatly in different directions , and it is in fact easy to demonstrate that reflexion of polarized light from such a surface at low angles is strongly directional

Making use of optomotor responses, I showed[5] that various dipterous (*Aedes*, *Drosophila*, *Thaumatomyia*) and other insects followed the rotation of a 'Polaroid' sheet under vertical illumination only when they were moving on or over dark reflecting material, but did not react against a bright background The existence of an objective brightness pattern in the light reflected at low sighting angles was again demonstrated , and movement of this pattern can explain the optomotor responses

Bainbridge and Waterman[3] showed that orientational responses to polarized light of the marine crustacean *Mysidium gracile*, previously reported by them, occur only when the water containing the animals is made turbid by the addition of yeast No significant results were obtained in carefully purified sea-water The orientational responses of *Mysidium* under a vertical source of polarized light thus seem dependent upon the discrimination by these crustaceans of differences of intensity in light scattered horizontally

Burdon-Jones and Charles[4] have shown that photonegative winkles of the species *Littorina littoralis*[4] move along the plane of polarization of light from an overhead source when it strikes them directly from above, even when the animals are allowed to crawl on a small ball in such a way that no light is reflected from the substrate The snails, however, orientate themselves equally well when their eyes are shielded from direct light and the only light they can see is reflected from the substrate Photopositive individuals orient themselves at right angles to the plane of polarization Burdon-Jones and Charles believe that in either situation the snails orient themselves with respect to a pattern of light and shade, perhaps arising from the Fresnel laws of refraction of plane polarized light, and that the animals do not possess any special powers of analysis whereby they could discern the polarized light in another way

Our knowledge of orientational behaviour in polarized light is as yet too scanty and insufficiently integrated to permit of a general resolution of the apparent contradictions, and in fact it is not at all certain that similar mechanisms operate in all situations where polarized light has been shown to produce orientational effects Some suggestions might, however, be useful One might distinguish between phototactic responses of animals which are correlated with the plane of polarization of light and the more complex perception and consequent utilization of polarization patterns in the blue sky as inferred for the bee by von Frisch Indirect directional effects of overhead sources of polarized light striking certain structures in the natural or experimental environment or in the dioptric apparatus and resulting in objective brightness patterns might frequently provide a sufficient explanation for the orientational behaviour of animals whether they in fact possess retinal receptors with analysing properties or not On the other hand, it is rather difficult to see how orientation with respect to small areas of blue sky could occur without such receptors. However, in many situations brightness gradients and polarization patterns in various parts of the blue sky are associated, and bees might in fact orient themselves to the former Furthermore, reflexion patterns caused by sunlight will often have their maximum brightness in the same azimuth as the Sun itself and the same applies to polarized light from a small area of sky reflected in a substrate. Thus the position of the Sun might be perceived by a bee directly or, when the Sun is invisible, its azimuth might be inferred from a brightness maximum in an area of the sky or a reflecting background The reactions of *Littorina* in the different conditions described above conform with such an explanation and might perhaps be taken to support this speculation

Another aspect of the orientation to polarized light might be mentioned finally, namely, its role in the life of the animals It is probably safe to assume that many of the observed reactions are merely experimental artefacts However, it is possible that, in other instances, orientation to sources of polarized light—however it works—may be of great ecological importance Progress in this field will depend on the careful weighing of evidence from such diverse techniques as electron microscopy, electrophysiology, photometry and not least from observations of the animals concerned

[1] Stockhammer, K , *Ergebnisse der Biologie*, **21**, 23 (1959)

[2] Baylor, E R , and Smith, F E , "Bees and Polarized Light" (Lecture Notes from Woods Hole Oceanographic Institute, 1958)

[3] Bainbridge, R , and Waterman, T H , *J Exp Biol* , **35**, 487 (1958)

[4] Burdon-Jones, G , and Charles, G H , XVth Intern Cong Zool , Sect XI, paper 10 (1959)

[5] Kalmus, H , *Nature*, **182**, 1526 (1958)

[6] Fernández-Móran, H , *Exp Cell Res* , *Supp* , **5**, 586 (1958)

[7] Wald, G , *Exp Cell Res* , *Supp* , **5**, 389 (1958)

OBITUARIES

Sir Ian Clunies-Ross, C M G.

Sir Ian Clunies-Ross, chairman of the Commonwealth Scientific and Industrial Research Organization (Australia), died on June 20 in Melbourne, Victoria, in his sixty-first year He was born at Bathurst, New South Wales, and educated at Newington College, Sydney He graduated as bachelor of veterinary science from the University of Sydney in 1921 and was awarded the degree of doctor of veterinary science of that University in 1928 After graduation he was awarded a Walter and Eliza Hall Veterinary Research Fellowship and undertook postgraduate studies at the London School of Tropical Medicine and at the Molteno Institute, University of Cambridge In 1928 he went to Japan for parasitological studies at the Institute of Infectious Diseases at Tokyo Imperial University

In 1925 Clunies-Ross was appointed lecturer in parasitology in the University of Sydney, and in the following year Council for Scientific and Industrial Research parasitologist When the C S I R McMaster Animal Health Laboratory was established in 1931 through the munificence of Sir Frederick McMaster, Clunies-Ross was appointed as the first officer-in-charge He held this position until 1937, when he was appointed Australian representative, and later chairman, of the International Wool Secretariat in London

Early in his career Clunies-Ross specialized in veterinary parasitology—a much-neglected subject in Australia at that time He saw clearly its great economic significance, especially to the sheep and wool industry, and applied himself to it so effectively that he quickly became one of the world's leading scientists in that field Although most of his work dealt with helminthiasis of sheep, his interest ranged widely among parasitological problems of other domestic animals and of man He brought to all his work a broad outlook and a depth of scientific understanding which inspired his colleagues and immediately won the confidence of the livestock industries Between 1923 and 1937 he published some sixty articles as sole author and a further fifteen as senior author , in addition, he was co-author of a text-book on the parasitic diseases of sheep

Realizing at the outset that the clarification and definition of the multiple and diffuse problems of ovine helminthiasis were essential if effective means of therapy and prophylaxis were to be devised, he instigated widespread surveys of the incidence and distribution of the major worm parasites of sheep, and of the associated climatic and other factors which determined their clinical significance Thus, for the first time a sound basis was laid for studies on epidemiology, host-parasite relationships and selective anthelmintic treatment He and his colleagues followed up with great vigour and enthusiasm the advantage this clearer understanding of the problem gave them, and progress flowed from it rapidly

Among his many outstanding contributions, Clunies-Ross was the first to record the effect of copper sulphate on closure of the œsophageal groove in sheep This opened up a new approach to anthelmintic treatment It was he who, by well-planned field trials, removed the fears of graziers that more intensive stocking of sheep on improved pastures would result in heavy losses from parasitism This led him to investigate the effects of improved pastures on the quantity and quality of wool production It was widely held that the well-being of the Merino and the quality of its wool depended on extensive, highly selective grazing, and that intensive grazing on the narrow range of species in sown pastures would result in coarse and inferior fleeces Clunies-Ross clearly demonstrated that not only can Merino sheep tolerate intensive grazing but also that they respond to the higher nutritional levels of sown pastures by producing much heavier fleeces with little change in fibre diameter

Clunies-Ross was an inspiring research leader He had the capacity to see problems clearly, to ask the crucial questions and to find ways of answering them effectively by laboratory or field experimentation His interest in veterinary research, however, and his choice of problems was always greatly influenced by his genuine love of animals This is well exemplified by the work in tick-paralysis of dogs, which was one of his most original and successful investigations He was then living in a part of Sydney where many hundreds of pet dogs died annually from the disease He was so moved by their suffering and by the distress of their owners that, in addition to all his other work, he took it upon himself to study this problem also Within three years he elucidated the epidemiology of the disease, traced its cause to a toxic factor in the salivary gland of the engorging female tick (*Ixodes holocyclus*), and prepared an antitoxic serum of high curative value This was typical of him , his interest was not in gaining new knowledge for its own sake but for the use which could be made of it Having once gained it, he used to the full his great gifts as a writer and public speaker to explain its significance to all who could apply it with advantage

Clunies-Ross's active personal research had to be laid aside when he joined the International Wool Secretariat Although he was appointed professor of veterinary science in the University of Sydney in 1940, he had little opportunity for scientific work, as he was called upon to serve during the war years as director of scientific personnel in the Commonwealth Directorate of Manpower and with the Department of War Organization of Industry as an adviser on the pastoral industry The War interrupted his scientific career, but it gave him opportunities to use his unique knowledge of Australian agriculture and his outstanding powers as a speaker and publicist to encourage and assist the remarkable growth of science and education in Australia during the years which followed In 1946 he joined the Executive Committee of the Council for Scientific and Industrial Research, and in 1949, when the Council was reorganized as the Commonwealth Scientific and Industrial Research Organization, Clunies-Ross became its first chairman He continued to maintain his close interest in the wool industry and played a large part in procuring the funds which enabled C S I R O to build up a major effort in sheep and wool research and wool textile research Throughout the pastoral industries his many friends had confidence in his judgment, and with their help and with the backing of the Government he had the satisfaction of seeing, towards the end of his life, a large body of scientists working enthusiastically on many problems of great national importance The major contributions which C S I R O has made to the agricultural development of Australia have been largely due to his outstanding and inspiring leadership

Clunies-Ross had many interests outside his scientific work The field of education was one in which he played a big part, and he was outspoken on the need for retaining breadth and liberalism in education He stressed repeatedly the dangers inherent in the increasing specialization of modern scientific and technological careers He played a large part in persuading the Government to set up the Murray Committee on Australian universities and made a major contribution to its outstanding report He was deputy chancellor of the University of Melbourne and a member of the Council of the Australian National University For many years he was active in the work of the Australian Institute of International Affairs and was well known as a public speaker on foreign affairs He was particularly interested in the relations between Australia and its northern neighbours As chairman of the International House of the University of Melbourne, a hall of residence in which Australian and overseas students live together, he was instrumental in making the idea a reality

Clunies-Ross was made C M G in 1954, and in the same year he was created a knight bachelor He was a foundation Fellow of the Australian Academy of Science He was awarded the honorary degrees of doctor of laws by the University of Melbourne, and doctor of science by the Universities of New England and Adelaide He is survived by Lady Clunies-Ross, three sons and one daughter

At the memorial service held in Scots Church, Melbourne, shortly after his death, Prof J D McCaughey, Master of Ormond College, University of Melbourne, made a fitting tribute to his memory He expressed in these simple terms the feelings of his many friends and colleagues throughout Australia and overseas "But in and through these achievements, it is Ian Clunies-Ross the man whom we remember with admiration, with respect and with affection to-day His capacity for work must have been enormous to die at sixty is young, yet into those years was packed an astonishing variety and depth of interests He lived a heavily committed life , yet, I suppose, that many of us in this Church think of him, with gratitude, as one who had time for friendship He accepted us with a smile It must have been given to few who have lived so fully, yet to be loved by so many"

F W G WHITE
D A GILL

Dr V Korenchevsky

DR V KORENCHEVSKY, who died suddenly on July 9, was born in 1880 in Russia and graduated from the Imperial Military Medical Academy in St Petersburg in 1903 After military service in Manchuria during the Russo-Japanese War, he worked in Metchnikoff's department at the Pasteur Institute in Paris and in Pavlov's laboratory in St Petersburg

In 1911 he was appointed professor of experimental pathology in the Imperial Military Medical Academy and remained there until the Revolution His disagreement with the policy of the newly formed Soviet Government made it necessary for him to leave St Petersburg and he escaped to south Russia, where he served as a doctor with the White Army for about a year After the defeat of the White Army he made his way to England and in due course became naturalized

During 1929–45 he was a member of the staff of the Lister Institute Afterwards he established the Oxford Gerontological Research Unit, with the support of funds provided by Lord Nuffield, and remained there until his retirement in 1952

The bulk of Korenchevsky's work between the Wars was primarily endocrinological and was concerned with studies of the effect of sex and thyroid hormones, separately and in combination, not only on the reproductive organs but also on the other organ systems of animals of different ages His work was characterized by a very close attention to detail, the use of first-class histological techniques and insistence on the need for healthy experimental material Korenchevsky regarded this work as a necessary preliminary to provide a rational basis for use of hormones in mitigating some of the degenerations which occur with ageing

Dr Korenchevsky will be especially remembered, however, for his pioneer achievements in stimulating interest in the field of gerontological studies His own concern with the problems of ageing went back to the early years of the century when he visited Russian infirmaries for old people, and during his stay with Metchnikoff in Paris he worked on the effects of gastro-intestinal autointoxication He always remained convinced of the value of Metchnikoff's theory, and he reaffirmed his belief in the importance of autointoxication as an ageing factor in several recent publications

By the late 1930's he felt that the change in the climate of opinion, for which he had been waiting, had come and that vigorous efforts to emphasize the need for gerontological research might at last be effective He therefore set out with the intention of developing an International Association of Gerontologists which would be responsible for investigations in all branches of the subject His efforts were just beginning to bear fruit when the outbreak of the War in 1939 brought them to an end for the time being

After the War, his retirement from full-time active laboratory work allowed him to extend his campaigning even more vigorously He was an outspoken advocate of the importance of gerontology, and in his missionary ardour he sometimes appeared intolerant of the ideas of others But any irritation engendered by his interventions were always more than outweighed by their stimulant effect, and it was clear to everyone that he was never seeking any personal advancement but only the benefit to his chosen subject which recognition might bring The results of his lifetime of strenuous effort will be found not so much in his large series of careful scientific publications as in the numerous national societies for the study of problems of ageing throughout Europe and the Americas, in the International Association of Gerontology and in the enhanced status which the subject has now acquired

P L KROHN

NEWS and VIEWS

Chief Scientist to the Ministry of Power

Dr C M. Cawley, C B E.

DR C M CAWLEY, C B E, has been appointed chief scientist to the Ministry of Power in succession to Sir Kelvin Spencer, who has retired from the public service Dr Cawley, who is fifty-two, has been at the headquarters of the Department of Scientific and Industrial Research for the past six years, where he has been responsible for administering general policy in relation to the work of the Department's research stations, and to grants made by the Department to the universities and other bodies, for the promotion of research and the training of research workers He is a University of London graduate with first-class honours in chemistry and joined the Scientific Civil Service in 1929, serving on the staff of the Fuel Research Station until 1953 He will take up his new appointment at the Ministry of Power in the early autumn

Ministry of Supply Appointments

Dr N. J L Megson

DR N J L MEGSON has been promoted to be deputy chief scientific officer and appointed director of materials, research and development (air) at the Ministry of Supply Headquarters Dr Megson studied chemistry at the University of Birmingham under Prof G T Morgan He obtained his B Sc in 1923 and his M Sc in 1925 He joined the Chemical Research Laboratory, Department of Scientific and Industrial Research, in 1927, as head of the Synthetic Resin Section and carried out fundamental and applied work on various aspects of polymers, particularly in the phenolic resin field

On the outbreak of war he was appointed to the Ministry of Supply as advisor on plastics and later became assistant director in charge of the Advisory Service on Plastics, Rubber and Paints, concerned with development and application of new and special materials for a variety of Service equipment In 1949 he was awarded the degree of D Sc by the University of Birmingham for a thesis entitled "Polymer Investigations" He became head of the Chemistry Department, Royal Aircraft Establishment, in 1951, responsible for research and development of non-metallic materials associated with aircraft and airborne equipment Dr Megson is the author of fifty or sixty publications, including a book, "Phenolic Resin Chemistry", and he has recently been awarded the Gold Medal of the Plastics Institute He succeeds Dr H Sutton, whose direct contribution to and sponsorship of work on light metals for aircraft construction has brought him deservedly wide appreciation

Dr B G Dickins, C B E

DR B G DICKINS, who has been promoted to be chief scientific officer and appointed as director general of atomic weapons in the Ministry of Supply, brings to that post wide knowledge of operational problems and experience of weapon development He obtained a first-class honours degree in physics in the University of London and entered the Civil Service in 1932 He served at the Royal Aircraft Establishment until 1936 and was then transferred to Air Ministry Headquarters He was attached to the Royal Air Force Station at Biggin Hill as the scientific officer associated with the now well-known air defence experiments which were initiated by Sir Henry Tizard and his committee When he returned to the Air Ministry he was still closely concerned with air defence problems and in addition became joint secretary of a committee under Sir George Thomson to advise the Government on the practicability of an atomic bomb He was for a time responsible for arranging the officially sponsored work in various universities In 1941, he was put in charge of the newly formed Operational Research Section, Bomber Command, which analysed the Command's operations from all aspects and made contributions to the knowledge available to the Command staff, which led to increased efficiency and improved operational methods After the War, at Air Ministry Headquarters, he assisted in the establishment of the peace-time organization of operational research in the Royal Air Force During 1948–1952 he was director of technical personnel administration in the Ministry of Supply where his main work was the planning of recruitment of technical staff particularly in the fields of guided weapons and atomic weapons He returned to the Air Ministry as deputy to the scientific adviser, whose duties were to advise the Air Staff on the influence of the new weapons on strategy and tactics and to direct operational research He was then appointed director of guided weapon research and development in the Ministry of Supply, where he was responsible for much of the Ministry's research and development work on guided weapons for all three Services In a reorganization in 1958 his work was concentrated on the development of the British intermediate range ballistic missile

Mr P. A Hufton

Mr P A Hufton has been promoted to become chief scientific officer and appointed head of the Aerodynamics Department at the Royal Aircraft Establishment in succession to Mr L F Nicholson, who is the new director general of scientific research (air), Ministry of Supply Mr Hufton graduated in engineering at the University of Manchester in 1933 and obtained his M Sc degree a year later He joined the Aerodynamics Department of the Royal Aircraft Establishment in December 1934 and after working for a short period on low-speed research, transferred to the Aerodynamic Research Flight where he remained until March 1946 Before the War, he worked part-time with C N H Lock at the National Physical Laboratory on propeller theory and experiments During the War he was responsible for take-off and landing research, particularly for heavily loaded aircraft, rocket-assisted take-off, development and flight testing of high-lift devices, and work on carrier landings for the Royal Navy In the spring of 1946 he moved to the Aeroplane and Armament Experimental Establishment at Boscombe Down as superintendent of performance He returned to the Aerodynamics Department, Royal Aircraft Establishment, Farnborough, in October 1953, in charge of the Supersonics Division and moved to the Royal Aircraft Establishment at Bedford as head of the Aerodynamics Division in September 1957 A year later Mr Hufton became chief superintendent of the Royal Aircraft Establishment at Bedford in succession to Mr L H G Sterne

Chemistry at the Royal College of Science and Technology, Glasgow :

Prof F S Spring, F R S

Prof F S Spring, who is retiring from the chair of chemistry in the Royal College of Science and Technology, Glasgow, graduated at the University of Liverpool under Sir Ian Heilbron and received his first appointment in 1930 in the University of Manchester, where he remained for sixteen years After Sir Ian Heilbron moved from Liverpool to the chair of organic chemistry in Manchester he and Spring worked in close collaboration over a number of years and made notable contributions to our knowledge of the chemistry of the sterols, vitamin D, and the triterpenes During this period Prof Spring's work was particularly associated with the structure of ergosterol and calciferol, and with the β-amyrin group of triterpenes Prof Spring was elected to the Freeland chair of chemistry at the Royal Technical College (now the Royal College of Science and Technology) in Glasgow in 1946 Here he has developed a flourishing school of research in the chemistry of the triterpenes and of certain heterocyclic systems Prof Spring was a Tilden Lecturer of the Chemical Society and was elected a Fellow of the Royal Society in 1952

Prof. P. L. Pauson

Dr Peter Ludwig Pauson, who has been appointed to succeed Prof Spring, graduated at the University of Glasgow with first-class honours in chemistry in 1946, and proceeded to Sheffield as holder of a Henry Ellison Research Fellowship There he worked under R D Haworth on purpurogallin and was awarded the degree of Ph D in 1949, having already shown his versatility by giving good service as temporary assistant lecturer in inorganic chemistry He spent the next four years in the United States, first as assistant professor at Duquesne University, Pittsburgh, then as Research Fellow successively at the University of Chicago and at Harvard It was then that he discovered the novel 'sandwich compound', dicyclopentadienyl–iron, usually known as ferrocene The interest aroused by this substance and its relatives was such that, less than four years later, Dr Pauson could publish a timely review article on work in this field, with eighty-eight references He returned in 1953 to the University of Sheffield, where he now holds the post of reader, vigorously pursuing the investigation of these remarkable substances, both as quite exceptional cases of metallic co-ordination and as organic aromatic systems of a new type

Nuclear Physics at the University of the Witwatersrand :

Prof. J. P. F. Sellschop

Dr J P F Sellschop has been appointed to the chair of nuclear physics at the University of the Witwatersrand as from July 1 He will continue to be director of the University's Nuclear Physics Research Unit, to which position he was appointed in 1956 Prof Sellschop, who at the age of 29 becomes the youngest professor in the University, is at present in Britain carrying out research at the Atomic Energy Establishment at Harwell for six months He is a member of the Research Advisory Committee of the

Atomic Energy Board and represented the Union at a seminar on atomic energy and its educational problems which was held in Saclay, France, under the auspices of the International Atomic Energy Agency in July. Prof. Sellschop was also an official delegate to the second International Conference on the Peaceful Applications of Atomic Energy in Geneva last year. Born in Luderitz, South West Africa, Prof. Sellschop received his early education at Christian Brothers' College, Pretoria. He then became a student at the University of Pretoria and received the B.Sc. degree there *cum laude* in 1950. After working at the National Building Research Institute in Pretoria for two years he was awarded an H. B. Webb scholarship and enrolled in the Merensky Institute of Physics at the University of Stellenbosch and in 1952 received the degree of M.Sc. *cum laude*. He then joined the Bernard Price Institute of Geophysical Research, later successfully reading for the Ph.D. degree in the nuclear physics group of the Cavendish Laboratory, Cambridge, as holder of a postgraduate scholarship awarded by the Shell Company of South Africa Ltd. in 1954.

Microbiology at Sheffield: Prof. S. R. Elsden

DR. SIDNEY REUBEN ELSDEN has been appointed to the newly created chair of microbiology in the University of Sheffield, as from October 1. Dr. Elsden was educated at the Cambridge and County High School for Boys and the University of Cambridge. He graduated B.A. in 1936 and obtained first-class honours in both parts of the Natural Sciences Tripos. During 1937–38 he worked under Dr. Marjory Stephenson in the Department of Biochemistry at Cambridge and was then appointed assistant lecturer, and later lecturer, in physiology in the University of Edinburgh. In 1943 Dr. Elsden joined the scientific staff of the Agricultural Research Council's Unit of Animal Physiology at Cambridge. He went to Sheffield in 1948 as senior lecturer in microbiology in the Department of Bacteriology and in 1952, when the University created a separate Department of Microbiology, Dr. Elsden was appointed head of the new Department. He has also been honorary director since 1952 of the Agricultural Research Council's Unit of Microbiology, which is housed in his Department. Dr. Elsden's Department has received generous support from the Rockefeller Foundation, and the Agricultural Research Council Unit has also received a grant from the Kellogg Foundation.

New Commonwealth Institute Building

PLANS for a new building for the Commonwealth Institute were made public on June 17. The new premises, which will replace the present accommodation in the Collcutt building in South Kensington, will be erected on a 3¼-acre site at the southern end of Holland Park, fronting Kensington High Street, at an estimated cost of £725,000. Work will start next spring and is scheduled for completion in 1962, when the removal of the Institute from its present building will be necessitated by Government plans for the expansion of the Imperial College of Science and Technology. The new Institute will consist of a main exhibition block with a wing on the western side. In the wing will be housed offices, a restaurant, a reception centre and dining space for visiting school parties. A large reception room for the Commonwealth Students' Club and for conferences and social occasions, a reference library and reading-room, a cinema to seat between 450 and 500, and a gallery specially designed for temporary art and other exhibitions are also included in the plans. The architects are Messrs. Robert Matthew and Johnson-Marshall. The Commonwealth Institute is the major centre in the United Kingdom for information about the Commonwealth nations and their Dependencies. Founded as the Imperial Institute in 1887, it has occupied its present accommodation in the Collcutt building since 1893. The name was changed from 'Imperial' to 'Commonwealth' Institute by the Act of 1958.

The British Non-Ferrous Metals Research Association

THE opening of the latest addition to the laboratories of the British Non-Ferrous Metals Research Association by Sir Alexander Fleck on May 13 is a further step in the progress of an Association which has grown in activity and reputation ever since it was first established some thirty years ago. This reputation in the field of non-ferrous metallurgy is acknowledged not only in Britain but also abroad. The restoration of the laboratories after serious war damage suffered serious delays, and with the increase in the Association's work and the resulting congestion, the decision was taken in 1957 to complete the building plans which had been formulated some twenty years earlier. The block now opened adds some 12,500 sq. ft. of floor space, bringing the total to about 53,000 sq. ft. It contains new corrosion laboratories, a large new metal finishing shop, extensions to the physics laboratories and to the foundry. Together with these a new council chamber and badly needed offices for the senior staff add considerably to the administrative amenities.

The Metropolitan-Vickers Nuclear-Metals Laboratory

IT was with the view of ascertaining the effects of irradiating metals that Metropolitan-Vickers Electrical Co. Ltd. decided to extend the existing facilities of the Research Department by building a Nuclear-Metals Laboratory. The Laboratory is equipped for the examination and testing of irradiated components and materials ranging up to a complete fuel element having an activity of the order of 10 kc. It is provided with two large concrete caves, and a train of five interconnected lead-walled cells is used to receive large irradiated objects. Essentially the caves are constructed of barytes concrete blocks. The air in the caves is arranged to be maintained at a slightly lower pressure than that in the open laboratory, thus ensuring that no air-borne radioactive dust can escape. Remote control manipulators enable the operations to be carried out inside the caves from outside the walls. The new laboratory will primarily be engaged on work for the Associated Electrical Industries—John Thompson Nuclear Energy Co., Ltd., and on work under contract for the U.K. Atomic Energy Authority. The scope of work will be concerned not only with investigations into the irradiation effects on constructional materials such as graphite and steel of various types, but also with establishing the behaviour of metals such as magnesium, zirconium, beryllium, etc., and of thermal and electrical insulation materials. A highly organized health physics service is maintained to safeguard the operating staff against all the hazards involved.

Sponsored Research in Great Britain

FACILITIES for sponsored research in Great Britain were increased by the formation in 1957 of the Arthur D Little Research Institute which has laboratories at Inveresk, Midlothian The Institute is a non-profit-making organization registered in Great Britain as a company under the Friendly Societies Act, and although the two concerns are separate, it operates in close association with a similar group in the United States, Arthur D Little, Inc , of Cambridge, Mass The Institute has now issued its first annual report from which readers may gain some idea of the scope and objects of the new venture With Lord Bilsland as chairman of the Board of Directors, and with Dr F N Woodward as director of research, the Institute has been concerned with several projects, all of which are being treated with special reference to the fundamental scientific background The results will normally be given open publication when the work is complete, and interim accounts of the various projects are given in this annual report These projects include investigations of the sodium derivatives of sucrose and of their condensation with a variety of organic halogen compounds, studies on the mechanism of the formation of isotactic polymers, the development of rapid methods for assessing the effectiveness of potential corrosion inhibitors, studies on the mechanism of inhibition of corrosion by electrochemical methods, and investigations into the modification of wood cellulose by chemical methods In addition, the report refers to lectures, publications and other scientific activities organized by the staff of the Institute It will be of great interest to all those who wish to know more about this new development in sponsored research and its place in the general organization of research in Great Britain

Nuclear Studies in the United Kingdom

THE Science Department of the British Council has issued its third list (May 1959) entitled "Nuclear Studies" This is a concise catalogue of courses in pure and applied sciences concerned with the use and development of nuclear energy It is issued primarily as a guide for the overseas student who wishes to undertake specialized, formal training in the United Kingdom Consequently it includes only full-time courses, generally of one week or more in duration, and is not concerned with research topics or with the courses which may be regarded as forming part of a normal first-degree course Although the list has appeared too late for application to be made for many of the courses during the academic year 1959–60, it serves to direct inquiries for courses in 1960–61 Further information can be obtained from the Science Department of the British Council, 65 Davies St , London, W 1

Building Research in New Zealand

IN recent years, a number of fields of investigation relating to the building industry in New Zealand have been pursued independently in various organizations and laboratories in which the main interests have been in quite different fields The Dominion (Chemical) Laboratory has investigated paints and local building materials , the New Zealand Forest Service has carried out work on timbers, both indigenous and exotic, suitable for building , the Pottery and Ceramics Research Association has investigated the appropriate use of brick constructions for earthquake conditions , and the Dominion Physical Laboratory has done some valuable work on methods of domestic heating, thermal insulation, and related physical problems But there has been no co-ordination between these diverse efforts , nor any institution wholly devoted to problems of the building industry

This anomalous state of affairs is now to be abolished with the establishment of a Building Research Bureau, which is being sponsored by a joint committee of the New Zealand Master Builders' Federation and the New Zealand Institute of Architects Dr Lyndon Bastings has been appointed the first director It is intended initially to set up a library and an information service , but as funds allow, it is hoped that laboratories and other practical facilities will follow in due course The address of the new Bureau is Construction House, 66 Murphy Street, Wellington, N 1, New Zealand

Postgraduate Courses at the Imperial College of Science and Technology, London

ADVANCED postgraduate study has long been a special feature of the work of the Imperial College of Science and Technology, University of London As new types of technology emerge—of which nuclear power and soil mechanics are notable recent examples —they open up possibilities of study which must remain outside the scope of any course for a first degree but which are properly within the field of university teaching The postgraduate courses at the College have been greatly increased in number in recent years to meet the wide range of technological development Postgraduate courses provide the opportunity for students, including many who have already spent a year or more in industry, to further their knowledge in a particular specialized field, and at the same time to learn from experts their experience of the application of this knowledge in industry. Details of the courses are set out in an impressive handbook published by the College (Postgraduate Courses, 1959–60 Pp xii+111 London Imperial College of Science and Technology, 1959) , the list should give considerable satisfaction to all who are concerned with Britain's place in the world of technology Many of these courses have been accepted by the Department of Scientific and Industrial Research as suitable for the tenure of advanced course studentships Grants for the courses related to agricultural science are awarded by the Ministry of Agriculture, Fisheries and Food The courses are assisted by industry , in particular, a number of firms support the work of the advisory committees in concrete technology and technical optics and provide bursaries for the respective courses

Sandwich Course in Executive Development

THE Department of Commerce and Management of Sheffield College of Technology is to provide a sandwich course in executive development commencing in November 1959 The purpose is to provide for the young manager and potential manager a fully integrated plan of executive development, by bringing together in one scheme both education for management within the College and general and vocational managerial experience in his working environment Full-time attendance at the College will be required for approximately fifteen weeks during each year of the course, and will be spread over a period of two academic years Only students already engaged in industry, and individually sponsored by their employers will be accepted into the course Further information can be obtained from the Head of the Department of Commerce and Management, 1, Melbourne Avenue, Sheffield, 10

Developmental Biology

THE first number has recently appeared of a new journal, *Developmental Biology*, published by the Academic Press, and produced by an editorial board consisting of Prof J Brachet, Prof E Hadorn, Dr P Weiss with Prof M V Edds of the Department of Biology, Brown University, as managing editor (*Developmental Biology*, Vol 1, No 1, April 1959 Pp x+124 Volume 1 (6 issues) 14 dollars New York and London Academic Press, Inc, 1959) The manuscripts in English should be sent to *Developmental Biology*, Department of Biology, Brown University, Providence, Rhode Island, U S A those in French to J Brachet, Laboratory of Animal Morphology, University of Brussels, Brussels, Belgium, and those in German to E Hadorn, University of Zurich, Switzerland Many of the classical divisions of biology no longer correspond to the way in which research is organized and thought develops in biology to-day The formation of this journal is an attempt to produce some degree of rationalization by bringing together studies of all aspects of development and growth This is well exemplified by the contents of the first number, which contains articles dealing with the chick embryo, with *Drosophila* larvæ, with the ribonucleic acid involved in differentiation of a fern and with the function of SH groups in morphogenesis In the editorial to the first number the editors say that they are prepared to accept articles written from a wide variety of points of view, for example, analytical or descriptive, technical or theoretical, using either a molecular approach and/or an organismal approach Micro-organisms plants and animals are all equally regarded as relevant to the problems of developmental biology

Native Life in Angola

THE Portuguese Companhia de Diamantes de Angola is noted for the interest it takes in archæology and the native cultures of the region in which it operates Business firms are not usually directly concerned with interests of a cultural nature outside their own money-making projects, and this makes it all the more remarkable that the Angola Diamond Mining Co has published already a large number of splendid volumes, full of illustrations which deal with many aspects of the past and present history of the country A recent volume (Companhia de Diamantes de Angola (Diamang) Servicos Culturais Dundo–Lunda–Angola Museu do Dundo Publicacões Culturais No 37 Flagrantes da Vida na Lunda Introducão de José Osório de Oliveira Pp 192 (Lisboa Companhia de Diamantes de Angola 1958)) is a superb publication of large format containing no less than 148 full-page illustrations of the countryside and its inhabitants. We can see basket-makers at work, fishing scenes, a moment in a divination ceremony, a Lunda chief with his robes and ceremonial insignia, etc The first 44 pages are devoted to an introduction by Dr José Osório de Oliveira, there being Portuguese, French, and English versions An account of some of the cultural activities of the company is given and also of the country and its people On the last page the author writes. "The honour attributed to the leaders of 'Diamang' in having anticipated in Africa that which the experts convoked by UNESCO counselled is nothing more than justice, for one cannot fail to look upon the company as the keystone of local native life" This is true, and furthermore, both archæologists and anthropologists all over the world have reason to thank the Company for the Dundo Museum and many other contributions to learning

Summer Tanager

FOLLOWING a series of depressions and strong westerly winds, an unusual bird was observed on Bardsey Island on September 11, 1958 It was somewhat smaller than a song thrush, olive green above and deep yellow below, with a heavy blunt bill and peculiarly short legs Subsequent observations suggested that the bird was a summer tanager, *Piranga rubra*, which had not previously been recorded in any European list, the few red feathers on the head and the back suggested that the specimen was a young male Details of the observation and of the highly successful work carried out at Bardsey Bird and Field Observatory during 1957 are described in the annual report of that Observatory for 1957, which can be obtained from W M Condry, Eglwysfach, Machynlleth, Montgomeryshire

Chromosome Numbers in *Solidago*

IN further studies of the genus *Solidago*, J R Beaudry and D L Chabot (*Canad J Bot*, 37, No 2, 1959) have observed the chromosome numbers in 25 taxa of the genus In all, the chromosome numbers of 42 taxa have now been published. The basic number of the genus is nine Thirty-three taxa are diploid ($2n = 18$), five are tetraploid ($2n = 36$), three are aggregate taxa containing both diploid and tetraploid cytodemes, and one is hexaploid ($2n = 54$) Polyploidy has thus contributed to the evolution of the genus *Solidago* but it seems that most of the species have differentiated gradually *S decemflora* DC of western North America differs from *S nemoralis* Ait of the same continent by morphological characters, its geographical distribution, and its chromosome number, the first taxon being tetraploid and the second diploid; the two are thus good species and not merely varieties of the same species *S rigida* is considered to be an aggregate, consisting of two entities which are distinguished not only by their morphology and geographical distribution but also by their chromosome numbers; the eastern one (*S rigida* L) is tetraploid, whereas the western one (*S parvirigida* Beaudry) is diploid. The bog and marsh goldenrods, *S Purshii* and *S uliginosa*, also possess different chromosome numbers, the first being diploid and the second tetraploid

Soil Fungi in the Belgian Congo

J MEYER has given a comprehensive account of soil and litter fungi in the Belgian Congo (region of Yangambi) (Publications de l'Institut National pour l'Étude Agronomique du Congo Belge Série Scientifique, No 75. "Moisissures du Sol et des Litières de la Région de Yangambi (Congo Belge)", par J Meyer Pp 211+4 planches Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1959 190 Belgian francs) In this work, the author has recorded his taxonomic observations on the very considerable number of fungi observed or isolated, leaving the questions of sociology, synecology, etc, to be dealt with later The generally accepted classification of soil fungi into native or cosmopolitan species, and exotic fungi (soil invaders), is followed, but the author notes that the exotic organisms require further sub-division into two groups, namely, preferent species (*espèces préférentes*), implying having precedence or priority, and exclusive species The nature of the vegetation, and the fruits, leaves and branches which fall from it to form the litter, carrying down air-borne organisms by which they have become infected, influences the nature of the exotic fungal flora So also do rhizosphere relationships Hence the author considers that the work of the soil mycologist must necessarily suffer limitations if it fails to take into account the nature of the vegetation and its litter, that is to say, properly envisaged, the phenomenon to be investigated is that of vegetation–litter–soil In this initial study, some 251 species are listed, described and many of them illustrated Of these, 191 came from the soil (13 Phycomycetes, 31 Ascomycetes, and 147 Deuteromycetes) and 60 were observed directly on debris The Hyphomycetes have been classified according to Hughes's system (1953)

Precambrian Geology of South-western Australia

The Precambrian geology of south-western Australia has recently been reviewed by A F Wilson (*J Roy Soc Western Australia*, 41, 57, 1958), who provides a new tectonic-geological map of a quarter of a million square miles of this region on a scale of 20 miles to the inch This is the first attempt to integrate all known trends of granites, gneisses, and 'greenstones', and on the map these and charnockitic rocks are distinguished for the first time The well-known north-north-westerly trend of the Goldfield areas is found to extend in a general way throughout much of the region The strike of the granites conforms to the regional strike of the metamorphic rocks, but magmatic emplacement is suggested locally Granitization contacts are also common, and filter-press differentiation phenomena are known Geochemical and petrographic features suggest that many gneisses are similar in composition to greywacke rocks, but that the granites would need to have been subject to some *K*-metasomatism to have been produced from such a source Charnockitic rocks are found over a very large area, and seem to have developed in at least four different ways, and in two main periods—one early and the other late Archæan It would appear from radioactive age determinations that the bulk of south-western Australia is of early Archæan age, and that a late Archæan period of metamorphism has affected parts of the south and south-east, and also possibly the western margin of the shield which is down-faulted beneath the Perth basin.

Perkin Centenary Trust Awards

The Perkin Centenary Fellowship has been awarded to Mr Brian Whitear, a research chemist in the laboratories of Messrs Ilford, Ltd Mr Whitear will work at the University of Southampton, under the supervision of Prof R C Cookson, on photochemical reactions of coloured substances Perkin Centenary Scholarships have been awarded to the following Mr Ronald R Cox (tenable at the University of Birmingham), Mr B T Lawton (tenable at the Royal Technical College, Salford), and to Mr D J Pearson (tenable at the Bradford Institute of Technology)

University News

Hull

The annual report, 1957–58, of the University of Hull notes the establishment of the grade of senior lectureship, to which eight lecturers have been promoted, and also another large deficit on the halls of residence Residence fees have been assessed to provide a surplus, and if costs do not rise appreciably an overall deficit should be avoided during the next three years The first stage of the new library building is expected to be completed in the summer of 1959 and a provisional building programme at an estimated capital cost of £949,000 has been approved by the University Grants Committee for the years 1960–63 including a new physics building, a hall of residence on the University site, an arts and social science building, and extensions to Ferens Hall The completed programme will cost nearly £2 million and will provide places in Hull for about half the 2,000 students expected in the University in the '60's The Senate's report includes brief notes on research work in progress, an account of the work of the Department of Adult Education and a list of publications during the year, arranged under departments

Announcements

H R H The Duke of Edinburgh has accepted an invitation to become the first Honorary Fellow of the Illuminating Engineering Society

Prof J H Mathewson, of the Institution of Transportation and Traffic Engineering, University of California, will give two lectures at the Road Research Laboratory, Langley Hall, Langley, Slough, Bucks, on "Experiments on Automobile Collisions" (September 9), and "A Simulator for Research on Driver Behaviour" (September 16) Both lectures will commence at 3 30 p m Tickets can be obtained (free) on application to the Director of Road Research, Road Research Laboratory, Harmondsworth, West Drayton, Middlesex

Sir James Denby Roberts has been appointed chairman of the Joint Committee of the Agricultural and Medical Research Councils and the Development Commission on Biological (Non-Medical) Problems of Nuclear Physics in succession to Lord Rothschild, who retired earlier this year This Committee was formed to sponsor and co-ordinate research on the effects of radioactive substances on plants and animals, and is responsible for the supervision of monitoring fall-out in foodstuffs and other biological materials Sir James is chairman of the Scottish Society for Research in Plant Breeding and is particularly interested in farming in the Highlands

It is announced that the Commonwealth Scientific and Industrial Research Organization (Australia) has formed a new Division of Mineral Chemistry, replacing the Minerals Utilization Section of the Organization's Chemical Research Laboratories The Division's research under the leadership of Mr R G Thomas will be concerned with the chemical transformation of minerals into a wide variety of useful products

A coloured wall-chart illustrating in section the Metro-Vickers Type *EM*6 electron-microscope has recently been produced primarily for the use of technical colleges and teaching institutions Supplies have been reserved for lecturers and science teachers and requests for copies should be addressed to the Publicity Department of Metropolitan-Vickers Electrical Co, Ltd, Manchester

INDUSTRIAL RESEARCH ASSOCIATIONS IN BRITAIN

"RESEARCH for Industry, 1958", which reports on work done by the industrial research associations in the Government scheme, this year adopts a new pattern which has much to commend it. It includes the report of the Industrial Grants Committee of the Council for Scientific and Industrial Research which comprises a review of grant policy during 1957–64 (see p. 211 of this issue), and a review of the achievements during the past five years of the ten research associations to which new or revised terms of grant were recommended during the year. Apart from brief notes on any outstanding features of the work of other research associations during the period, the bulk of the report comprises a list of existing associations, giving their officers, total income and publications during the year and a brief note on the scope of the present work of each association. There is also an assessment by Dr. D. T. A. Townend of the place of the research associations in the evolution of scientific endeavour, and a report entitled "New Ideas, New Products, New Processes" on how co-operation research serves the textile industries. In this report, which covers the work of several research associations, the point is made that one-fifth of an association's resources is only adequate for fundamental research if the total resources are big enough.

Of the research associations which received new or revised terms of grant during the year, stress is laid on the basic research into the composition of gelatin and glue, the structure of the gelatin molecule, the properties of solutions and gels and the conversion of collagen into gelatin being carried out by the British Gelatine and Glue Research Association; the economic value of the work of the British Hat and Allied Felt Makers' Research Association; the achievements of the British Hydromechanics Research Association in the design and utilization of pumps and in high-pressure hydraulic machinery and in hydraulic model testing. The Furniture Development Council has conducted a basic investigation into factors affecting the strength and rigidity of cabinet construction, developed test methods for furniture lacquers and worked on a new, economical material—wood chipboard. The Heating and Ventilating Research Council began its first major research project in 1956–57—an investigation of problems arising from the intermittent heating of buildings, with the view of ascertaining possible fuel savings by choosing in advance equipment and programme of the daily heating cycle in relation to the thermal characteristics of the building and installation. The Lace Research Association has carried out much work on new types of yarn and on problems arising in dyeing and dressing synthetic fibre materials, and is engaged in a basic study of the bobbin and carriage, which is the central feature of major types of lace machines.

Basic research carried out by the British Flour-Millers' Research Association includes a complete analysis of the amino-acid composition of flour and of the changes which occur when it is made into bread. The Research Association of British Rubber Manufacturers has extended its cover to plastics, notably polyvinyl chloride and polyethylene, and has been investigating the basic physical characteristics of rubber and plastics and the influence of service conditions such as temperature on these characteristics. An outstanding piece of chemical research increased knowledge of how traces of certain metals, notably copper and manganese, can cause premature deterioration of important classes of rubber products, especially rubber-proofed fabrics. The British Coke Research Association has developed instruments such as an isothermal bomb calorimeter for accurate determination of the calorific value of solid and liquid fuels and an electromagnetic semi-microbalance for use in fundamental studies relating to carbon.

AGRICULTURAL RESEARCH IN BRITAIN

A CORRESPONDENT, commenting in a Scottish farming paper on the Report of the Agricultural Research Council for 1957–58, complained that he could find no reference to research on grass tetany. Because of its current seriousness, he felt that some of the four million pounds that the Council administers should be allocated directly towards research into this problem. If he had read the report with deeper understanding he would have realized that such a criticism was not really justified. For example, at the Rowett Research Institute there are in progress fundamental studies on the physiology of rumen digestion with particular reference to young grass which is high in potash and nitrogen. The work is not labelled grass tetany or hypomagnesæmia, but it is in fact just the sort of work that will lead to a better understanding of the metabolic diseases of livestock which are still very largely unsolved. Agricultural research has long since passed from its old phase of an empirical approach to outstanding problems, and this is well illustrated by this report, for the main emphasis is on fundamental studies necessary for a better understanding of the vital mechanisms of plants and animals.

Another illustration of this approach is provided by the investigations, mainly at Rothamsted Experimental Station and at the University of Durham, into the biology of the potato root eelworm. Studies have been made of diffusate from potato roots which stimulates hatching of the cysts, and investigations are proceeding at several centres into the chemistry of this material, with the view of obtaining a means of causing hatching in the absence of the host plant.

A feature of the report is the very considerable emphasis which is given to the several aspects of poultry research, which for a number of years was something of a Cinderella so far as the Council was concerned. The industry, with an annual output of £200 millions, is second in importance in Britain to dairying, and it also is one of the most heavily subsidized. It is very important that the industry should be more efficient, and especially is this true in respect of disease control, for wastage is a very heavy source of loss To-day there are two poultry research institutes, one wholly and the other partly financed by the Council, while there is a considerable amount of poultry research being supported at other centres One pleasing aspect of the breeding work is the attention that is being given to methods which will be within the compass of the small breeder, who is in imminent danger of being squeezed out by the large organizations producing hybrid chicks

Possibly the most notable advance from the point of view of the farmer relates to the control of husk in cattle, which is caused by the lungworm, *Dictyocaulus viviparus* This work has been undertaken by the University of Glasgow Veterinary School and was started in 1952 The successful outcome of this work is that double vaccination, using doses of larvæ that have been partially inactivated by irradiation with X-rays, gives an effective field control of a disease which has been a serious source of loss to farmers The cost to the cattle industry has not been confined to deaths and loss of thrift, but has included also the cost of housing and hand-feeding susceptible animals in order to avoid infection Now that farmers have an effective control of the disease, it will be possible for them to put calves out to pasture and thereby considerably lower the cost of rearing X-irradiation opens up enormous possibilities in the control of other endo-parasitic infections, and further work is proceeding on this side

One final point about the Council's activities—though the greater part of its funds go to research institutes such as Rothamsted Experimental Station and the National Institute for Research in Dairying, the universities are by no means neglected Apart from a number of research units, there were ninety-four separate projects at sixteen universities which were receiving grants in March 1958 It seems that fears expressed a few years ago that the big institutes would monopolize research in agriculture, and the sciences basic to agriculture, are groundless, for it is obviously the Council's policy to encourage workers at the universities, who have, among their other duties, the task of training research workers to staff the institutes

SELF-REGULATION IN LIVING SYSTEMS

THE first Ottawa symposium on self-regulation in living systems, held in October 1958 (see *Nature*, 183, 730 , 1959), led to requests for a second meeting with particular emphasis on problems of stability in self-regulating systems This meeting was held at the National Research Council laboratories in Ottawa on March 11 As on the previous occasion, a very wide range of professions was represented, and the attempt was made to increase our understanding of the behaviour of living systems by analogy with known physical and mathematical techniques and concepts

The opening paper, outlining the nature of the problem, was by a physiologist, Dr A S V Burgen (McGill University, Montreal) Burgen emphasized that all physiological problems are multifactorial in character, and that in a real biological system it is impossible to isolate a single variable A real need exists for more adequate mathematical techniques to deal with such problems However, at present, simplifying assumptions are essential in order to reduce problems to manageable form Thus we may, for example, consider the blood circulatory system as made up of two pumps—namely, the right and left ventricles of the heart—connected in series with each other and with the blood vessels of the body The problem here is how the outputs of the two pumps are maintained equal to one another It is found that over a wide range of input pressures the output flow is proportional to this pressure, and in this way automatic regulation is achieved It appears that blood pressure is controlled by sensors acting via the base of the brain to cause dilation or contraction of capillaries in the circulatory system In these cases, and, for example, in the problem of maintenance of body temperature, the mechanisms by which the actual operating values are determined remain largely unknown at present It was also pointed out that there are definite time-cycles within the body for which at present no explanations have been given Following Burgen's paper there was considerable discussion as to whether the dependence on temperature of the rate of chemical processes might provide an adequate mechanism for the maintenance of an internal temperature standard

Dr A C Smith (Computing Centre, University of Ottawa) presented some analysis of the properties of idealized control systems, using the method of the Laplace transformation The analysis, however, was limited to strictly linear systems, and it was felt that the *non*-linear problem is in fact of great importance to physiologists and others The conclusion reached in the analysis was that optimum control conditions obtain when the control action depends upon both the variable under control and its time derivative This conclusion agreed with the general experimental observations of the physiologists present In the discussion the influence of time delay or phase of negative feedback on the stability of systems was of primary interest Physiological systems discussed in this connexion included problems of neurological instability and the recent work, reported in the literature, on the relation between stammering and delays in the reception of aural signals The galvanometer amplifier using a light beam and photocell to provide a high degree of negative feedback offers a simple mechanical system showing some of the important features If the time delay in the response of the cell is appreciable, the galvanometer amplifier system may 'build up' to a state of oscillatory instability It should be emphasized that the polarity of the feedback is still nominally negative , if the feedback is connected up in the opposite sense (positive feedback) then the galvanometer amplifier becomes entirely unstable, and obviously so !

An outline of some modes of operation of digital computers by Dr Bradford Dunham (Research Laboratory, International Business Machines, Poughkeepsie, New York) opened the way for analogies to be drawn with living systems In programming a computer a specific problem must be given a precise mathematical formulation and then translated into machine language Under these conditions we may say that the machine will either perform activities requiring no 'judgment', or it may be adapted to include activities requiring 'judgment' provided that the programme contains some means for evaluating consequences We can then go further and consider problems which are rather inexact, or poorly defined, with the condition that the answer(s) to the problem (which may be very difficult to find) must be easy to check or recognize as correct when arrived at In order to do this, the machine changes its own programme in some successive manner and at the same time evaluates the effect of these changes It certainly appears that this technique of 'machine search' can be regarded as a learning process (perhaps even more ?) in that the machine itself attempts to arrive at the correct way to tackle a problem

Dr F L McNaughton (Montreal Neurological Institute) made some remarks on stability in relation to the human system, pointing out first that we are still far from an adequate understanding of how the brain works Experiments in which people were isolated from their environment result in hallucinations in the experimental subject and some distortion of perception when the period of isolation is ended, a clear interdependence of nervous system and environment is indicated When this adjustment of man to his environment breaks down he shows the symptoms of disease Broadly speaking, it appears that only damage or disease in the general receptor or motor areas of the brain produce immediately identifiable external symptoms Considerable parts of other areas of the brain may be removed or quite drastic surgery carried out, with what appear to be only transient after-effects in many cases In discussion, the close analogy between the apparent organization of the human brain and the problem of 'machine search', mentioned above, was pointed out It has been found that in machine 'learning' of this type, the initial and final stages of the programme (which might perhaps be likened to receptor and motor areas) are critical in the solution of the problem, but otherwise many alternative programmes appear to be possible

Dr G Glinski (Department of Electrical Engineering, University of Ottawa) spoke on the general problem of stability and adaptability of multi-loop feedback control systems Systems of this type are much closer to living systems than the simpler control systems discussed earlier since a number of variables are involved in controlling a single output In addition, there may be feedback to one or more inputs and it is also possible to take into consideration some interaction between input variables

In the previous symposium, Dr A C Burton (University of Western Ontario) presented some demonstrations on the significance of visual perception The present symposium concluded with a short demonstration by Dr Burton of interaction between visual inputs This followed an experiment first performed by Mach in which an interaction between neighbouring receptors in the eye leading to a sharpening of the contrast between light and dark regions is shown quite dramatically by the apparent presence of intensified dark and light bands in the penumbra region of a straight edge when projected on to a lantern screen

Following the meeting, a panel discussion took place on the Canadian Broadcasting Corporation system under the chairmanship of Sir Robert Watson-Watt, in which Drs Burgen, Dunham and MacDonald took part During this spontaneous discussion the significance of 'learning' by machines was explored further It is probable that a further symposium will be held—perhaps this time in Montreal

D K C MACDONALD
DOUGLAS L MARTIN

THERMONUCLEAR PROCESSES

A CONVENTION on "Thermonuclear Processes" was held in the Great Hall of the Institution of Civil Engineers on April 29–30 The convention was organized by the Institution of Electrical Engineers in conjunction with the British Nuclear Energy Conference A total of twenty-two papers were read, half of which were concerned exclusively with the engineering problems arising out of research into controlled thermonuclear reactions The remaining papers were largely re-statements of results given at the Geneva Conference on the Peaceful Uses of Atomic Energy last year, albeit presented in a form more suitable for a predominantly engineering audience However, some new results were given, particularly in the papers submitted by the United States and the U S S R

The mechanism of energy loss remains the outstanding question in connexion with the toroidal stabilized pinch or *Zeta*-type discharge At the Geneva Conference, Dr S A Colgate of the University of California claimed that the entire energy loss during the first 7–8 μsec of the discharge life-time in his small torus was due to runaway electrons with an energy of about 2 keV striking the walls Later, Drs Hughes and Kaufmann of Associated Electrical Industries, Ltd, Aldermaston, published results obtained with the *Sceptre* apparatus showing that impurity ions were drifting around the torus with the unexpectedly high velocity of 10^6 cm/sec The angular momentum of the deuterium plasma deduced from these measurements was in agreement with the notion of runaway electrons as the chief source of loss This happy unanimity was destroyed by the release of two further results during questions at the Convention First, a search had been made on *Zeta* for the Doppler shift in impurity spectra indicating drift motion and none had been found Secondly, the group at Los Alamos under Dr J A Phillips working with *Perhapsatron S*4 had some evidence to show that the whole of the energy loss from their torus was due to radiation in the vacuum ultra-violet region Clearly more work will have to be done before the problem is finally resolved

Mr G B F Niblett of the Atomic Weapons Research Establishment, Aldermaston, described some new experiments on the rapid compression of plasma In this work a fast-rising axial magnetic field is created inside a linear discharge tube by means of a long single-turn copper coil coupled to a condenser bank The resulting ring discharge ionizes the gas and is rapidly collapsed by the rising magnetic pressure The heating principle is the same as that of the fast linear pinch first reported by Kurchatov at Harwell in 1956, but the changed geometry avoids electrode effects and is expected to be hydromagnetically more stable A ringing discharge with a frequency of about 200 kc /s was produced in a $1\frac{1}{2}$-in bore tube A rotating-mirror photograph of the discharge in nitrogen showed successive contractions of the discharge corresponding to the oscillations of the coil current In other measurements, the radial oscillation of the hollow cylindrical shell of plasma when confined between two magnetic fields was observed It was suggested that these oscillations might be used to heat the plasma

A paper presented by Mr J D Jukes of the Atomic Energy Research Establishment, Harwell, analysed a system for extracting electrical energy directly from any fusion reactor which uses the principle of magnetic confinement To extract the energy, the plasma is taken through a compression cycle by varying the confining magnetic field During the compressed state, energy accumulates in the plasma due to the burning of the nuclear fuel When expanded the plasma temperature is low so that fusion reactions occur infrequently and the plasma cools, losing energy by bremsstrahlung radiation In this way, waste heat is removed from the plasma and a closed Carnot cycle can be achieved Since the neutrons produced in the fusion reactions are unaffected by the magnetic field, only the energy released in charged particles can be extracted in this way Mr Jukes concluded that it should be possible to withdraw about one-third of the available energy from proposed fusion devices directly as electrical energy

Dr C M van Atta of the University of California Radiation Laboratory presented a survey of the very large American programme in this field which costs 40 million dollars a year and employs three hundred professional staff A new experiment demonstrating the propagation of torsional Alfvén waves through plasma was described To produce the plasma a linear discharge carrying a current of 20 k amp in an axial magnetic field of 10 kilogauss is used The waves are generated by applying an alternating radial electric field between one of the electrodes and the conducting wall of the tube The measured velocity of propagation increases linearly with the axial magnetic field strength and is in close agreement with theory if the ion density is assumed to correspond to all the gas initially in the tube being ionized This work is being done by Dr J Wilcox at the Radiation Laboratory, Berkeley Among other experiments reported in this paper were hydrodynamic stability studies by Dr S A Colgate using high current pulses through sodium, and similar studies by Dr H P Furth using plasma and a variety of magnetic field configurations

An important consideration in the magnetic-mirror method of confinement is the accuracy of the assumption that the magnetic moment of a spiralling charged particle is a constant The principle of mirror confinement is based on this adiabatic invariance, and since a confined particle may undergo many millions of reflexions from the mirrors during its containment, the accuracy required is of a high order In experiments by Dr E Lauer of Berkeley, positions with energies of the order 1 MeV resulting from the β-decay of radioactive neon were shown to be contained between magnetic mirrors for 10^8 reflexions The distance between the mirrors was 1 m and the Larmor radius of the electrons 6 cm

Dr I N Golovin of the Institute of Atomic Energy, Moscow, gave an account of research into magnetic-mirror systems in the Soviet Union He described an experiment on the adiabatic invariance of the magnetic moment similar in principle to that reported by Dr van Atta In this case electrons from the radioactive decay of tritium were used and confinement for up to 10^7 reflexions had been demonstrated Work had also been done to find the effect of azimuthal asymmetries in the magnetic field on the number of reflexions It was found that until the azimuthal variations in the magnetic field strength exceeded about 10 per cent there was no effect on this containment The remainder of Dr Golovin's paper was devoted to a discussion of the work on *Ogra*, the large Russian mirror machine He stated that *Ogra* was built to study plasma instabilities and was designed to produce a hot plasma with a density of 10^{12} ions/cm ^{3} if no instabilities were encountered The principle of injection in this machine is that of dissociation of the input beam of 200-keV molecular ions through collisions with the residual neutral gas in the volume By balancing the favourable process of dissociation against the unfavourable one of charge exchange, it can be shown that a dense plasma will only be formed if the input beam current exceeds a certain value, the so-called burn-out current The burn-out current for *Ogra* was calculated assuming that the background neutral gas density was determined by the ionization of neutral gas by fast ions and by the release of neutral gas from the walls through the impact of fast particles A figure of the order 200 m amp was obtained for the formation of a hydrogen plasma Another assumption in the calculation was that the path-length of an injected molecular ion moving in the magnetic field and failing to make a collision should be not less than 10^5 cm before it returns to the injector This length depends critically on the magnetic field configuration and the ion gun alignment, and one of the first tasks with the machine will be to optimize these A very low initial pressure is also required and to date the lowest value achieved has been $\sim 3 \times 10^{-8}$ mm mercury In view of the size of the vacuum chamber, 1 5 m bore and 20 m long, this represents a considerable technical achievement The present ion-source gives 150 m amp of molecular ions at 100 keV Up to the moment only a 30-m amp beam of ions has been injected into the machine and the burn-out condition has not been achieved Impressive photographs were shown of the beam spiralling in the magnetic field

During question time, Dr K W Allen of the Atomic Weapons Research Establishment, Aldermaston, raised the subject of the order of magnitude difference in the relevant charge exchange cross-sections as measured by Fedorenko in the U S S R and by Barnett in the United States Replying, both Dr van Atta and Dr Golovin declared their faith in the measurements carried out in their respective countries, but Dr van Atta hoped that the work would soon be repeated in a third and preferably neutral country Other points raised during discussion periods concerned the importance of the spectral region 10 A – 400 A for plasma measurements, the power lost by synchrotron radiation from the electrons in a magnetically confined plasma and the need for more work on surface bombardment effects

Finally, Sir George Thomson called for more refined experiments, with purer plasma and more homogeneous magnetic fields He concluded by declaring his faith in the ultimate solution of the problem of obtaining economic power from fusion reactions

R BICKERTON

BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION

NEW RESEARCH LABORATORIES

ON May 13 Sir Alexander Fleck, chairman of Imperial Chemical Industries, Ltd., opened a new laboratory block for the British Non-Ferrous Metals Research Association at Euston Street in London. The laboratories have gradually been extending on this site since 1930 and now contain about 53,000 sq. ft. of floor space and house a staff of about 180. They serve the needs for co-operative research of practically all branches of the non-ferrous metals industry, and the 40–50 research projects in progress cover the production, properties and uses of the commoner non-ferrous metals, certain aspects of the metallurgy of the metals concerned with nuclear energy, and metal finishing.

The new laboratory was made possible by the generous response to a building fund on the part of the Association's membership of more than 600 firms and of the Department of Scientific and Industrial Research, which has treated contributions as grant earning. The main features of the new block are a much-enlarged foundry, new corrosion and physics laboratories and a new electroplating shop. Alterations to existing buildings have enabled a new creep testing laboratory to be built which will allow the capacity to be doubled to more than 100 units, the rehousing of many different types of fatigue testing machines in one room, and the provision of more space for the General Metallurgy Section. This, among other things, gives the Section more room for vacuum apparatus for the determination of gases in metals.

In the foundry, moulds are now made in one well-equipped bay and poured in an adjacent melting and casting shop. The melting equipment consists of five gas-fired lift-out crucible furnaces, a gas-fired bale-out furnace for research into die-casting problems, a 600-lb. low-frequency induction furnace for studying the performance of refractory linings, and also an electric resistance furnace and a high-frequency furnace each capable of melting charges of up to 20 lb. of copper or nickel alloys in vacuum or special atmospheres.

From the inception of the laboratories the value of physical methods of analysis has been realized and the Association's work in developing spectrographic analysis of metals to its present state of efficiency is well known. Recently, the X-ray fluorescence method of analysis has aroused considerable interest and it appears extremely promising for analysing the major constituents in alloys and for the analysis of ores and slags. Its potentialities are being studied, using a spectrometer designed by the Physics Section and built in the Association's workshops. In the Chemistry Section emphasis is on the physico-chemical methods of analysis, including polarography, spectrophotometry and the use of the flame spectrophotometer.

The Physics Section has two X-ray diffraction sets and a variety of special-purpose cameras for crystal orientation studies, the identification of phases in compounds and other tasks. An electron diffraction camera is available for studying oxide and other thin films on metal surfaces.

Instrumentation for automatic inspection and process control is becoming increasingly important in the metal industry, and several studies are being made of problems in this field. They include the use of eddy currents for rapid inspection of tubes and rods for flaws, an investigation into emissivity variations of hot metal surfaces which affect the performance of radiation pyrometers, and the development of a novel thermo-electric gauge for measuring, non-destructively, the thickness of electro-deposits.

Research on electroplating and allied metal-finishing processes is now housed in a large new laboratory equipped both for fundamental work and for plating on a semi-industrial scale in pilot plating lines. Equipment is available for measuring the stresses during plating, for measuring cathode potentials and throwing power, and for assessing the ductility and adhesion of coatings. Exposure tests on plated specimens are carried out on the roof of the laboratories, but much work has been done on accelerated corrosion tests, including one in which the parts are exposed to a humid atmosphere containing traces of sulphur dioxide which simulates in a few hours the effects of exposing the parts to a city atmosphere for several months.

Many modern plating solutions contain organic additions which affect the smoothness, brightness and mechanical properties of the coatings in a beneficial way. Exactly how these organic agents do this is not known, and typical addition agents prepared with tracers, such as carbon-14 and sulphur-35, are being used to study the mechanism of the process.

In the Corrosion Section one laboratory is employed solely for sea-water corrosion studies, the current work being concerned mainly with the attack on heat-exchanger tubes handling heavily polluted estuarine waters in power stations, oil refineries and in ships. Some of these tests are at controlled potentials to simulate the effects of applied cathodic protection. The influence of marine atmospheres is assessed by exposure at a site on Hayling Island and the laboratory roof site is used mainly for inland tests. Stress corrosion tests are carried out at both these sites and there is also a special high-humidity room for this purpose in the corrosion laboratory.

One of the main uses of non-ferrous metals is the handling of supply waters, and the effect of water composition on the resistance to corrosion of various metals is being studied at field stations and also in the laboratories using synthesized waters.

The General Metallurgy Section, besides carrying out the usual metallographic work, heat treatment and constitutional studies, contains a metal-working shop with a 12-in. rolling mill, a 500-ton press for extrusion and forging, a small forging hammer and a drawbench. This section of the laboratories is also working on the development of titanium, zirconium and thorium alloys and has argon-arc melting equipment appropriate for this type of work. Special apparatus which uses an atmosphere of argon for carrying out long-term creep tests on these reactive metals is housed in the new creep laboratory.

HIGHER EDUCATION IN EAST AFRICA

IN 1954, a delegation, headed by Dr. (now Sir) Eric Ashby, was appointed to assist in planning the development of Makerere College, Uganda. In addition to indicating the general scope of the development which it thought appropriate, the delegation also made reference to the broad problem of developing higher education in East Africa as a whole. As a result, a working party, under the chairmanship of Sir Alexander Carr-Saunders, visited East Africa in July 1955, to review in greater detail the requirements of higher education. Its findings were published in a White Paper[1], in which the Governments of Kenya, Tanganyika, Uganda and Zanzibar fully accepted the desirability of further university college development, within the scope of a single University of East Africa.

A second working party, under the leadership of Dr. J. F. Lockwood, visited East Africa in July 1958 to examine proposals for the creation of new institutions of higher education, in particular within the framework of a University of East Africa.

Its report[2], recently published, contains four main recommendations, which are being considered by the East African Governments: (1) By re-organization and extension, the Royal Technical College of East Africa, in Nairobi, should, without delay, become a university college of a new type, in which academic and professional courses of equal standing would have their place with Faculties of Science, Arts, Engineering and Special Professional Studies. (2) That plans should be formed for the establishment of an inter-territorial university college in Tanganyika at Morogoro, to be opened in 1965–66, or as soon thereafter as possible. (3) That a university of East Africa should be created by 1966 and that the university colleges then existing, and any which may be founded thereafter, should be associated as constituent colleges of the university. (4) Since the carrying out of these recommendations will guarantee adequate provision for higher technological and professional training for some years ahead, no additional institutions offering facilities for these kinds of training should at present be contemplated.

If these recommendations are accepted the new University of East Africa would have as its constituent colleges, Makerere College, the Royal College of East Africa (the reorganized Royal Technical College) and the new university college in Tanganyika. The report adds: "The inter-racial character of the colleges we take for granted as an indispensable element in their fully liberal nature and outlook". That they should also be wholly inter-territorial was likely for many years to be a vital necessity in terms both of academic need and of finance.

It is suggested that since the college in Nairobi would begin its career as a university college under the same system which now applies to Makerere College, students of the reconstructed college would work for degrees of the University of London, under a scheme of special relationship. The University of East Africa, following its foundation, would grant its own degrees, for which students of all the colleges would read. Since the university college in Tanganyika would probably not begin its teaching until after 1966, students of this college would, at the outset, read for degrees of the newly established university.

Though realizing that its proposals are modest, the working party stresses that the cost, in terms both of capital and recurrent expenditure, will be high, and points out that the several Governments will be unlikely to be able to meet capital expenditure from their own joint resources. "The compulsion of their present circumstances will thus force them to lean heavily on expectations of generous grants from Colonial Development and Welfare funds."

The report concludes with the hope that financial help will be forthcoming, for the individual colleges, from non-official sources, and pays tribute to generous gifts, which the Gandhi Memorial Academy Society has made to the Royal Technical College.

C. MORTIMER

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[1] Higher Education in East Africa. Pp. 123. (Entebbe, 1958.)

[2] Report of the Working Party on Higher Education in East Africa, July-August 1958. Pp. ii+48. (Nairobi: Government Printer, 1959.) Sh. 3.

GLOEOSPORIUM IN APPLE STEM WOUNDS

TWO contributions on *Gloeosporium* in apple stem wounds have recently appeared (*J. Hort. Sci.*, 32, No. 2, 1959). R. O. Sharples has reported on an investigation of the response of apple stems to wound infections by the fungus *Gloeosporium perennans*. In anatomical studies relating to the establishment of infections on apple branches he has shown that the defensive mechanism of the host includes the production of suberized barriers by bark phellogens and the blocking of xylem vessels by gum deposition. These responses follow wounding, whether or not the wounds are inoculated with *G. perennans*, but the presence of the fungus delays the response. Accordingly the size and form of lesion induced by inoculation are largely determined by the effect of the fungus in postponing the normal wound healing process. This effect, and consequently penetration by the pathogen, is greatest during the period of host dormancy. Invasion occurs most rapidly through the sieve-tubes and the vessels and fibres of the outer xylem; the longitudinal intercellular spread of hyphæ through the cortex is slower.

Intracellular infection of the pith and medullary ray cells occurs in pruning-wound infections. When the progress of the infection is arrested, the phellogen and cambium lay down barriers of callus tissue consisting of parenchymatous outer cells surrounding a core of wound wood. After the lesion has been thus isolated, the fungus persists as a saprophyte and eventually forms acervuli on the exposed dead host tissue. A limited spread of infection past the suberized barriers occasionally appears to take place by way of the fibre bundles of the inner cortex

On the same topic, A T K Cooke has observed that *Gloeosporium* inoculations of pruning wounds on apple shoots are unlike branch wounds in that the cut tips of shoots are more or less susceptible to infection throughout the year, and that, although the extent of the infection is subject to the same host reactions as in lateral branch cankers, the normal healing process may be affected by seasonal conditions This emerged in a comparison of the behaviour of infected pruning cuts made on shoots at comparable times in successive years Sporulation on infected shoots was found to be greater in November than in March infections, beginning in both instances after one month Infections initiated during July first spored in December and produced very few conidia Like the branch infections studied during 1953–54, the shoot cankers yielded considerable numbers of conidia in the warm, wet months of December 1956–February 1957 The peak spore collection from the shoot cankers was in the June and July following inoculation, this being also a peak period for sporulation on the branch cankers

AIR SURVEYS AND THE SOCIAL SCIENTIST

By LEO SILBERMAN
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CO-OPERATION between the air survey team on one hand, and economists and social surveyors on the other, is likely to be greatly extended in the near future During the War photo-interpreters had to get along without systematic ground checks, and the relative rarity of combined studies of area sample surveys using questionnaires and air photographic coverage must be ascribed to a legacy from war-time

The advantages of combined operations are distributed equally between photogrammetrist and social student To the uses already made of air photography, the insights of the social scientists capable of interpolating more social and economic information from the records add further facts to those already known To the questionnaire survey the air photograph gives a much greater generality The samples can be extrapolated by multiplying the data for each typical unit by the total of this stratum found on the photographs This will provide an up-to-date sampling frame which in under-developed countries (though not only there) is usually lacking[1] By defining unambiguously the strata of which a regional population is composed, facilitating greater control, and allowing the ground surveyor to dispense with a large, often ill-educated and sketchily supervised staff, a better and speedier report can be furnished , this is often of great 'political' importance to the client The time factor is sometimes crucial

Photogrammetrist and sociogrammetrist in such a combined survey make their decisions together on the most practical scale of photography , the size of the ground sample that will give confidence in the statistical estimates , and the planning uses to which the results can be put Quantitative information is only part of the expected findings attention is often focused on the use made of space and the configuration of a neighbourhood However, social statistics will always cover a wide field, ranging from the count of slum properties to evidence of the spread of sleeping sickness

Air censuses taken of nomads in Palestine in the days of the British mandate and the censuses of Liberia and of Columbia both taken from the air are quantitative assessments of this kind Land-use studies in Malaya, making good use of the expensive photographs taken during the anti-terrorist campaigns and supplemented by family budget studies in that country, can be mapped so that hypotheses can be tested with the use of overlays A real property inventory is essential to a sociogrammetric survey but the use of such a survey in national and regional income investigations and capital growth and change studies is still to be fully appreciated

Regional comparisons are particularly important where there are jealousies between areas, and each claims self (that is, locally based) government, as in a number of West African countries, irrespective of whether it is economically feasible By giving the discussion some underpinning of fact the scales might conceivably be tipped towards a rational economic solution By comparisons between cognate regions we can appraise to what extent, with like endowments, policy or location has made labour and capital more productive Is it a nearby market, or education, or a longer period of peace that explains differential incomes of similar regions ? The analyst will not only wish to discover, as in the Gambia study of the Directorate of Oversea Geological Surveys, whether more rice is grown (a matter of political importance and controversy) but also why more rice is grown The term 'survey' implies study before planning A country like Ceylon taking a measure of its real resources, a project of the Colombo Plan, will also need to find out about its man-power, both quantitatively and, by the style of houses and state of agriculture, qualitatively[2] The Sudan not only wants to know where irrigation is technically feasible but also where there are Sudanese willing to take advantage of the arable land The country cannot absorb a limitless influx of foreigners from the west and north without creating a security problem

Once a clear picture emerges how an area works, the siting of a technical college or a new village becomes clear In built-up areas of rapid expansion public utility companies will want to know where and how the towns are spreading, so that offices can be strategically located, space reserved, and telephone lines not be intersected by other services above and below ground[3] The ground survey establishes to what extent houses are being subdivided and branch or independent line subscribers being added The state of the yards and many other things will tell us whether the area is improving or deteriorating In each area contrary influences are at work, each seeking dominance, as they spread from the various centres, and the racial strife of so many cities shows what bad neighbours peoples of different antecedents and standards of living make[4]

'Ecological statistics' can give in figures the area 'profiles'[5], for air photographs do not speak to everyone equally eloquently, just as maps and tables are permanent mysteries to some, unable to learn the conventions of each idiom or keep standard comparisons in their heads The aggregation of many individual values into composite, ecological statistics offers no problem to modern computing devices, which also are capable of mapping electronically information fed into them by some scanning apparatus in an aeroplane

Airborne radar, duplicated perhaps with magnetometers and gravitometers, adds to the sensitivity and completeness of the record Not only images but also radio waves, power points and carbon dioxide can be 'photographed' Infra-red photography picks up besides the aeroplane on the airfield the heat of the runway and thus the number of planes recently started The emphasis in modern photogrammetry has thus shifted from the static physical condition to the recordable human transactions

In brief, there are three chief ways in which such a survey can be used

(1) To supply general social and economic statistics such as the presence and growth of industry, agriculture, house building, road improvements, conservation and productivity, cross-checked with ground social surveys and nationally or regionally collected annual or census statistics

(2) The planning of policy and of improvements and services is based on these surveys A deft handling of photographic material should be combined with opinion studies and other studies on the ground, such as traffic and migration counts done by mechanical or human agents

(3) The evaluation of policy, that is, the effectiveness of any constructive activity This will probably be done increasingly as part of ordinary photogrammetric work with the help of someone competent in statistics and sociology and with a knowledge of the particular part of the world that is to be studied At a later stage, perhaps, when many different studies have been accumulated and compared, the skilled social interpreter may also be able to make useful deductions from a study of the photographs unaided by ground studies

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[1] Silberman, L , *Zaire*, 68 (1955)

[2] "The Significance of the Canadian–Colombo Plan to the Economic Development of Ceylon" (Hunting Technical Services) (Toronto, 1958)

[3] Chicago Aerial Industries have recently done such studies for a telephone and a gas company Mimeographed reports (1959)

[4] Green, N E , and Monier, R B , "Reliability and Validity of Aerial Reconnaissance as a Collection Method for Urban Demographic and Sociological Information" (Maxwell Air Force Base, 1953)

[5] Duncan, O T , *Population Studies*, 27 (1957)

EMISSION OF RELATIVELY HIGH-ENERGY IONS FROM LOW-VOLTAGE ARCS

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SOME interesting effects have been observed with low-voltage arcs for which so far no completely satisfactory explanations have been found The principal effect observed is the emission of luminous rays consisting of ions of the cathode material at energies much greater than the total potential difference across the arc

In the experiments described below, the arc is formed between a tungsten, molybdenum or tantalum filament, which is separately heated, and a nickel anode at a distance of about 5 cm , and is maintained in a rare gas, usually argon, at a pressure of 1–50 mm mercury The applied potential difference is 40–80 V and the current is 200–500 m amp The arc is thermally constricted or 'pinched' to a diameter of approximately 5 mm In arcs of this kind[1] the electrons, ions and gas molecules are in an approximate thermal equilibrium at a temperature generally of the order of 10^4 °C The ionization potentials of tungsten, molybdenum and tantalum are lower than the excitation potentials of the rare gases and in the present experiments the arcs therefore tend to consist of ions formed from metal volatilized from the cathode[2] Spectroscopic analysis of the arc reveals strong W II and W I (Mo II and Mo I) lines but only a few faint argon lines

The first effect observed is that tungsten is deposited at the point where the arc makes contact with a cool nickel anode This deposition occurs even when the anode is screened from any material evaporated directly from the hot cathode The rate of deposition on the anode, as determined by activation analyses, is typically 3×10^{-6} gm /sec $^{-1}$ amp $^{-1}$, equivalent to a tungsten ion current of 1 5 m amp in an arc of 1 amp It appears that in hot cathode – cool anode arcs of this type there is an efficient mechanism for transporting positive ions from the cathode to the anode against the electric field It is evident that such a transport mechanism is required if the ions in the arc are formed originally from volatilized cathode material in the immediate vicinity of the cathode

A second effect is observed when the arc is constricted by a small aperture of ½–1 mm diameter in a nickel diaphragm placed between the cathode and anode, as shown in Fig 1 The cathode is now about 5 cm from the aperture diaphragm, and the anode is about 10–20 cm , or preferentially, the anode has a coaxial aperture of 2–3 mm diameter and is spaced about 5 mm from the first aperture, as is shown in Fig 1 On the anode side of the apparatus the pressure is maintained within the range of 10^{-1} to 10^{-3} mm mercury As a result of the constriction, impressive luminous white rays are observed projecting from the centre of the small aperture into the low-pressure region Occasionally, the rays form a uniform diverging beam, as in Fig 2, but more often

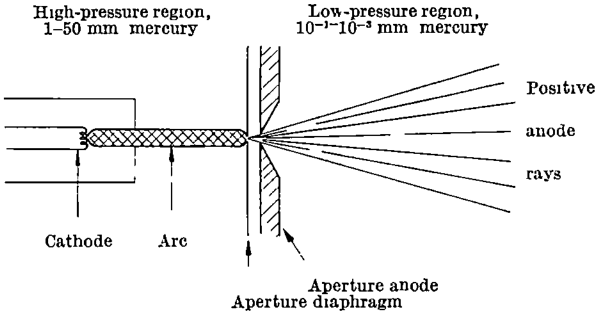

High-pressure region, 1–50 mm mercury
Low-pressure region, 10^{-1}–10^{-3} mm mercury
Positive anode rays
Cathode
Arc
Aperture anode
Aperture diaphragm

Fig 1 Apparatus for producing a constricted arc which ejects energetic positive ions through the aperture anode

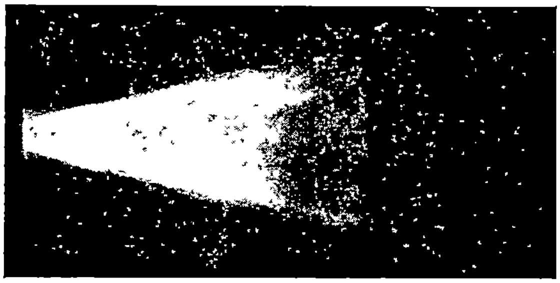


Fig 2 Positive tungsten ion rays of approximately 450 eV accelerated by an argon arc of 250 m amp and 80 V

the beam is divided into several individual rays of small diameter which flicker and move in synchronism with the instability motion of the arc Spectroscopic analysis of the deposit formed by the rays incident on a receiving target shows that the rays consist of tungsten atoms On changing the cathode material to molybdenum, the deposit formed by the rays is found to consist only of molybdenum, but the luminosity of the rays is unaltered and their colour only very slightly affected

Electrostatic and magnetic deflexion experiments establish the surprising fact that the rays are positively charged and have energies greater than the potential difference across the arc The accelerated ions are reasonably monoenergetic and have an energy in the range 100–750 eV , depending on the conditions of the arc With an aperture reduced to ½ mm diameter and a pressure of 80 mm mercury in the arc, tungsten ion rays with energies greater than 1,000 eV have been observed with a potential difference of only 60 V across an arc of 500 m amp Rays may also be observed when the pressure is as low as 1 mm mercury , in this case the arc develops only in a limited region adjacent to the aperture in a form reminiscent of a 'ball of fire'[3] The rays are not so easy to produce when the supporting gas is either helium or neon, possibly because the arc currents in these experiments are limited to relatively small values With krypton and xenon the rays are produced as readily as in the case of argon

Difficulty is encountered when attempts are made to measure electrically the current in the tungsten ion rays, not only because of secondary electrons but also because there is apparently an electron flux which is not easily eliminated Activation analyses of deposits formed by the rays incident on a target show that in a typical case there is a total flux of 0 4 × 10^{-6} gm /sec $^{-1}$ amp $^{-1}$ equivalent to 0 2 m amp in an arc of 1 amp This is consistent with the fact that a large fraction of the tungsten migrating towards the anode is deposited around the aperture More intense fluxes, up to 1 m amp per ampere of arc current, can be achieved by applying an alternating potential difference of 20–50 V between the cathode and an enclosing cylindrical electrode The flux and luminous intensities do not appear to be critically dependent upon the frequency in the range 10^4 to 10^7 c /s , and it is possible that the increase in intensity is due to the enhanced fluctuation movements induced in the arc

Potential fluctuations of up to 20 V. of the electrodes and movable probes have frequencies of 10^4–10^5 c /s. with a wide spectrum of 'hash' superimposed The fluctuations in luminosity of the rays as detected by a photomultiplier are similar to those of the arc and reveal frequencies in the same range as the potential variations The emission spectrum of the rays is predominantly W II, or in the case of a molybdenum cathode, Mo II

A third effect observed is that the rays frequently show a pronounced variation in intensity of luminosity along their length Thus, if the rays are projected into a region of low pressure of 10^{-3} mm mercury, in a typical case all rays are bright for the first 2 5 cm , the luminosity then becomes faint for about 0 5 cm , and then abruptly increases in intensity and thereafter diminishes slowly up to distances as great as 30 cm

A completely satisfactory explanation has not been found for all the effects described The luminosity of the rays is most probably due to charge exchange between the tungsten (molybdenum or tantalum) ions and the supporting gas , the abrupt variations in the luminosity, however, are not understood The mechanism responsible for producing the positive anode rays is most probably associated in some way with the transport of ions in the arc from the cathode to the anode The oscillatory or 'hashy' nature of the arc may be an essential self-sustaining feature[4] Thus, sound waves will be propagated with a phase velocity of $(\gamma kT/m)^{1/2}$, where m is the mass of the atoms of the supporting gas, and one possibility is that the electric fields produced by the separation of the electrons and ions are sufficiently large to cause a fraction of the ions to move with a drift velocity of approximately $(e\lambda E \sin\varphi/m)^{1/2}$ in phase with the sound waves, where λ is their mean free path, E is the oscillatory electric field, and φ is the phase angle Experiments designed to detect the propagation of signals along the arc at the phase velocity of sound have not been entirely successful, and the evidence is meagre and unconvincing Possibly the arc is in a turbulent state, and generates and propagates sound waves only over small distances

If disturbances of approximately 1 mm wavelength are propagated in the arc, the potential fluctuations suggest that the associated electric fields are of the order of 400 V cm $^{-1}$ In the region of the constriction the oscillatory electric field might be expected to increase inversely as the diameter of the arc, giving a value of 6 × 10^3 V cm $^{-1}$ if allowance is made for the fact that the arc is smaller than the constricting aperture It is therefore possible that the ions gain their energy of several hundred electron volts from the oscillatory electric fields in the constricted region of the arc

Energetic ions of several hundred electron volts have been observed elsewhere[5] in high-current, low-pressure arcs in magnetic fields used in the DCX experiments However, the arc conditions are considerably different and the accelerating mechanism is not necessarily of the same kind as that proposed above

Acknowledgments are made to Mr J D Lawson, Prof A von Engels, Dr P C Thonemann and Dr S A Ramsden for their suggestions and interest, to Mr D H F Atkins for the activation analyses and to Mr F T Birks for the spectroscopic analyses of the ray deposits

[1] See review articles Dryvesteyn, M J , and Penning, F M , *Rev Mod Phys* , **2**, 87 (1940) Francis, V J , and Jenkins, H G , "Rep Progr Phys ", **7**, 230 (1940) Jones, F Ll , "Rep Prog Phys ", **16**, 216 (1953) Finkelnburg, W , and Maeker, H , "Handbuch der Physik", **22**, 254 (Springer-Verlag, Berlin, 1956) Lochte-Holtgreven, W , "Rep Prog Phys ", **21**, 312 (1958)

[2] Suits, C G , *Phys Rev* , **55**, 561 (1939)

[3] Malter, L , Johnson, E O , and Webster, W M , *R C A Rev* , **12**, 415 (1951)

[4] Donahue, T , and Dicke, G H , *Phys Rev* , **81**, 248 (1951)

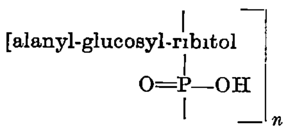
[5] Neidigh, R V , and Weaver, C H , Proc 2nd Geneva Conference, 31, 315

TEICHOIC ACIDS FROM BACTERIAL WALLS

FROM THE DEPARTMENT OF CHEMISTRY, KING'S COLLEGE (UNIVERSITY OF DURHAM), NEWCASTLE UPON TYNE

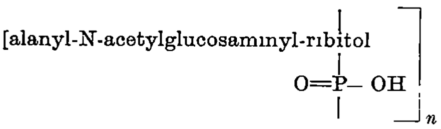
Composition of Teichoic Acids from a Number of Bacterial Walls

INVESTIGATIONS on the function of the nucleotides cytidine diphosphate glycerol[1] and cytidine diphosphate ribitol[2] led to the discovery of a new group of natural polymers, the teichoic acids, in the walls of certain bacteria[3] In *Bacillus subtilis* the teichoic acid is of the type shown in formula (1), whereas that in *Staphylococcus aureus* has the related structure (2), in which the sugar component is glucosamine That from *Lactobacillus arabinosus* is of the type (1), but some of the ribitol residues bear two glucosyl substituents, whereas others are unsubstituted by glucose A more detailed discussion of their structure and relationship with cytidine diphosphate ribitol has been given elsewhere[4]



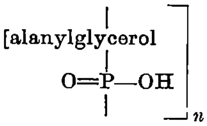
$$\left[\begin{array}{c} | \\ \text{alanyl-glucosyl-ribitol} \\ | \\ \text{O}{=}\text{P}{-}\text{OH} \\ | \end{array}\right]_n$$

(1)



$$\left[\begin{array}{c} | \\ \text{alanyl-N-acetylglucosaminyl-ribitol} \\ | \\ \text{O}{=}\text{P}{-}\text{OH} \\ | \end{array}\right]_n$$

(2)



$$\left[\begin{array}{c} | \\ \text{alanylglycerol} \\ | \\ \text{O}{=}\text{P}{-}\text{OH} \\ | \end{array}\right]_n$$

(3)

We had intended to confine the term 'teichoic acid' to those polymers of ribitol phosphate of the general structure (1) or (2) found in bacterial walls A more extended survey of other organisms (see Table 1) has shown that some bacteria contain a new type of teichoic acid in which ribitol has been replaced by glycerol Preliminary studies on the hydrolysis of these glycerol derivatives by acids, or by alkali followed by prostate phosphatase, show that they have the structure (3) Visual chromatographic estimation indicates that they represent more than 30 per cent of the wall in some cases Consequently, the restricted nomenclature originally adopted must now be modified to include all polymers of the types (1), (2) and (3)

The polyol phosphate derivatives in walls of *L arabinosus* and *B subtilis* are clearly ribitol-teichoic acids of the type (1), and no trace of a glycerophosphate polymer has been detected in these walls All strains of *Staph aureus* examined so far contain a ribitol-teichoic acid (2) ; but these walls also contain either traces, or in one case a considerable amount, of a glycerophosphate polymer Similarly, walls of *Streptococcus faecalis* contain a ribitol teichoic acid of the type (1) and a glycerophosphate polymer

It is interesting that *L casei*, *L delbruckii*, *L bulgaricus*, *Staph albus*, and *Staph citreus*, unlike the other lactobacilli and staphylococci examined so far, contain glycerol-teichoic acid but no trace of a ribitol-teichoic acid The compound from *Staph albus* and *Staph citreus* was present in their walls , but preparations from whole cells were used for the work on the three lactobacilli and it is not known whether the teichoic acid in these preparations originated from the walls The compound from *L casei* is of the type (3) in which alanine is attached to a polymer of glycerophosphate The amount of hexose in preparations of this material is very small and we have been unable to demonstrate any glycosylglycerol linkages It seems likely that all the glycerol–teichoic acids in the bacteria listed will be of type (3) , but the presence of glycosyl residues is still possible in some cases

In addition to the organisms discussed here, a number of others yielded small amounts of glycerophosphate on acid hydrolysis of their walls There is evidence that polyols other than ribitol and glycerol are present together with these in teichoic acid preparations from some organisms, and sugars other than glucose or glucosamine may occur

Extracts prepared from whole cells of all organisms examined contained a glycerophosphate polymer, even when no such polymer was present in the isolated walls It is not known whether this is a teichoic acid of type (3) which has been lost from the walls during their preparation or whether it is associated with other cell structures

In contrast to the variations in polyol and sugar, the only amino-acid found in purified preparations of teichoic acid is alanine This amino-acid isolated from teichoic acid from *L arabinosus* and *Staph aureus* has the D-configuration[5] It was shown earlier that the alanyl residues are in ester linkage and it is now found that the lability of these residues (half-life 5 min at 37°, *p*H 7 2, 1 1 *M* hydroxylamine) in neutral salt-free hydroxylamine solution is comparable to that of amino-acids bound to ribonucleic acid (half-life 3 min at 30°, *p*H 7 2, 0 8 *M* hydroxylamine)[6] The alanine ester linkages are therefore much more reactive than normal amino-acid esters which do not react significantly with hydroxylamine under comparable conditions[7]

Table 1

	Type of polymer	
	Glycerol	Ribitol
Lactobacillus arabinosus 17-5	–	+
L casei (A T C 7469)	+	–
L delbruckii (N C I B 8608)	+	–
L bulgaricus (N C I B 76)	+	–
Staphylococcus aureus H	trace	+
Staph aureus (Duncan)	trace	+
Staph aureus (Oxford)	+	+
Staph citreus	+	–
Staph albus (N C T C 7944)	+	–
Bacillus subtilis (vegetative form)	–	+
Escherichia coli (Type B)	trace	–
Corynebacterium xerosis	+	–
Streptococcus faecalis (A T C 9790)	+	+

D-alanine has been demonstrated as a characteristic component of a number of bacterial walls[8–10]. Snell, Radin and Ikawa[8] showed that in *Strep. faecalis* about 40 per cent of the D-alanine of the walls can be extracted with hot trichloroacetic acid in a bound form which is described as "especially labile to alkaline hydrolysis". The similarity in properties and method of extraction of this material and of teichoic acid suggests that these authors had obtained preparations containing teichoic acid.

The unifying feature in all teichoic acids is the presence of alanine ester linkages. If we confine this nomenclature to polymers of types (1), (2) and (3) containing such linkages, they are thus distinct from simple glycerophosphate polymers prepared from bacterial walls and membranes[11], although it is possible that the latter have originated from teichoic acids by loss of alanine groups during isolation.

We thank Drs. M. R. J. Salton, G. D. Shockman, E. P. Abraham and D. E. Hughes for samples of bacterial walls and for advice on their preparation. This work was supported by grants from the Medical Research Council, the Nuffield Foundation and the Rockefeller Foundation.

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Structure of Teichoic Acid from the Walls of *Bacillus subtilis*

THE walls of *Bacillus subtilis* contain a large amount (about 50 per cent of their dry weight) of a teichoic acid[4] in which alanyl–glucosyl–ribitol residues are joined together through phosphate groups to form a polymer. Previous work had shown that each ribitol residue bears one glucosyl substituent and one alanine group in ester linkage with either a sugar- or ribitol-hydroxyl group. Recent findings indicate that the alanyl residues have the D-configuration in teichoic acid from *Staphylococcus aureus* and *Lactobacillus arabinosus*[5], and it is possible that the compound from *B. subtilis* will be a D-alanine derivative.

Hydrolysis of the teichoic acid from this organism with alkali and then prostate phosphomonoesterase gave a single glucosylribitol, but the scale of operations was small and this compound was not isolated[4]. From a larger-scale experiment crystalline glucosylribitol has been obtained in high yield, m.p. 137–138°, $[\alpha]_D$ − 28·6° (*c*, 0·1 in water) (found C, 41·8, H, 7·6. $C_{11}H_{22}O_{10}$ requires C, 42·0, H, 7·1 per cent). It seemed unlikely that the glucose was attached at the terminal 1(5)-position of the ribitol, since periodate oxidation, followed by reduction of products with sodium borohydride and then acid hydrolysis[12], gave glycerol but no ethylene glycol. Moreover, if the glucosyl residue was attached to position 3 in ribitol the compound should give a yellow colour on paper chromatograms sprayed, with the periodate-Schiff reagents for glycols[13]. The glucosylribitol gave the normal purple colour in this test, thus indicating the absence of the glucose at the 3-position.

The structure 4-β-D-glucopyranosyl-D-ribitol (4) was established by periodate oxidation. It consumed 4 mol. of periodate and gave 1 mol. of formaldehyde and 2 mol. of formic acid; it follows that the glucosyl substituent must occupy the 2- or 4-position on the ribitol. The compound was readily hydrolysed to glucose and ribitol by a β-glucosidase, and its specific rotation agrees well with those reported for β-D-glucosides.

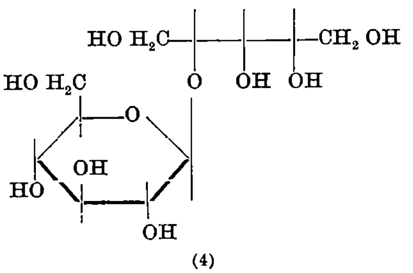
The trialdehyde formed by periodate oxidation contains two glyceraldehyde residues, one originating from the glucose and the other from the ribitol. That from the glucose must have the D-configuration, whereas that from the ribitol would have the D-configuration if the glucosyl substituent were originally at the 4-position on the ribitol, or the L-configuration if the glucosyl substituent were originally at the 2-position. Consequently, the structure (5), arising from 4-β-D-glucopyranosyl-D-ribitol (4), would be optically active, whereas the isomeric structure from 2-β-D-glucopyranosyl-D-ribitol would be a meso-compound.

The periodate-oxidation mixture exhibited a low positive rotation after removal of ions, even when kept for several hours under acidic conditions at room temperature. It was possible, however, that cyclic acetal formation in the trialdehyde might invalidate conclusions on its steric configuration. Consequently, the aldehyde was oxidized with bromine to the corresponding tricarboxylic acid. Without isolation this was hydrolysed with acid, and the resulting glyceric acid was examined polarimetrically as its ammonium salt in the presence of molybdate ions[14]. A positive rotation was observed even from the small amount (32·3 mgm.) of glucosylribitol used in these experiments. It follows that the trialdehyde has the structure (5), and hence the structure (4) is established for the original glucosylribitol.

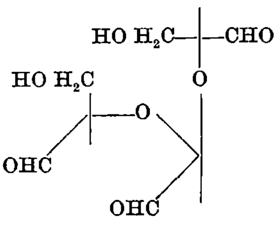
It is interesting that teichoic acids from different organisms may vary in the configuration of their glycosyl residues. The teichoic acid from *Lactobacillus arabinosus*[4], and the monoglucosylribitol obtained from it, are unaffected by β-glucosidase and have the specific rotations expected from α-glucosides (experiments with Dr. A. R. Archibald).

A sample of teichoic acid from *B. subtilis* was treated with ammonia under mild conditions to remove the alanine residues, and the product was oxidized for 24 hr. with periodate. Not more than a trace of anhydroribitol, and no ribitol derivatives, were detected in an acid-hydrolysate of the oxidation mixture, thus indicating the presence of unsubstituted glycol groups in the ribitol residues. It follows that the phosphodiester linkages must be situated at positions 1 and 5 or 3 and 5 on the 4-glucosylribitol units.

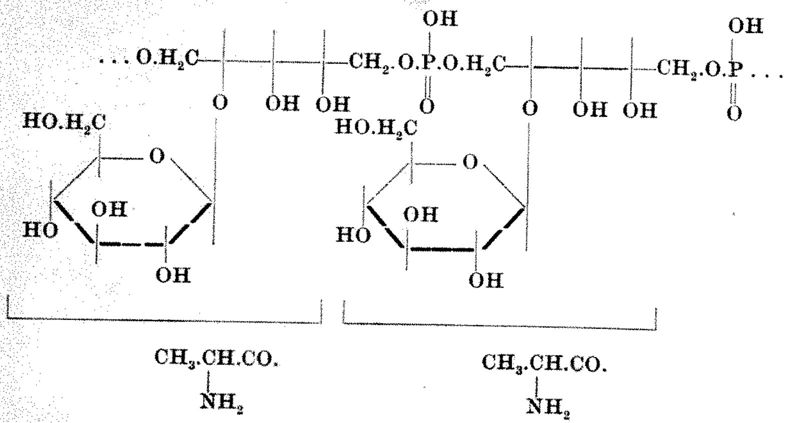
The teichoic acid in this organism almost certainly originates from cytidine diphosphate ribitol[2]. This nucleotide contains a D-ribitol 5-phosphate residue[13] which is apparently transferred intact into the polymer.



(4)



(5)



(6)

Alkaline hydrolysis of the teichoic acid occurred readily and completely, giving a mixture of monophosphates of glucosylribitol; only traces of diphosphates, and no phosphodiesters, were detected among the products. All the glucose was released from this mixture by a β-glucosidase, the other products being ribitol 1- and 2-phosphates; these phosphates were identified chromatographically[13]. It is noteworthy that the enantiomorphs, ribitol 5- and 4-phosphates, would be indistinguishable from the 1- and 2-phosphates on paper chromatograms, but nevertheless could not have been formed by the action of alkali on a polymer of 4-glucosylribitol 5-phosphate. As no trace of the readily identifiable ribitol 3-phosphate was detected among the products it follows that the phosphodiester linkages are at positions 1 and 5 in the polymer (6).

The structure (6) for this teichoic acid was confirmed by removal of alanyl residues with ammonia, purification of the resulting polymer by passage of the solution through a column of 'Dowex-50' resin, and oxidation with periodate. For every 3 mol. of periodate consumed, less than 0·2 mol. of formaldehyde was produced, thus indicating the almost complete absence of unsubstituted 1,2-(or 4,5-) glycol groups in the ribitol residues. The formaldehyde liberated in this experiment presumably originated in a terminal ribitol residue; but molecular weight estimations based on the amount of formaldehyde produced may not be reliable.

The presence of a trace of ribitol in a dephosphorylated alkali-hydrolysate of this teichoic acid suggests that a very small proportion of the ribitol residues in the polymer lacks the glucosyl substituent. The location of such residues, and the location of the highly reactive alanine ester groups, are not yet known.

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[1] Baddiley, J., Buchanan, J. G., Mathias, A. P., and Sanderson, A. R., *J. Chem. Soc.*, 4186 (1956).

[2] Baddiley, J., Buchanan, J. G., Carss, B., and Mathias, A. P., *J. Chem. Soc.*, 4583 (1956).

[3] Armstrong, J. J., Baddiley, J., Buchanan, J. G., and Carss, B., *Nature*, **181**, 1692 (1958).

[4] Armstrong, J. J., Baddiley, J., Buchanan, J. G., Carss, B., and Greenberg, G. R., *J. Chem. Soc.*, 4344 (1958).

[5] Baddiley, J., and Neuhaus, F. C., *Biochim. Biophys. Acta*, **33**, 277 (1959); and unpublished work with Dr. A. R. Sanderson.

[6] Berg, P., and Ofengand, E. J., *Proc. U.S. Nat. Acad. Sci.*, **44**, 78 (1958).

[7] Raacke, I. D., *Biochim. Biophys. Acta*, **27**, 416 (1958).

[8] Snell, E. E., Radin, N. S., and Ikawa, M., *J. Biol. Chem.*, **217**, 803 (1955).

[9] Salton, M. R. J., *Nature*, **180**, 338 (1957).

[10] Park, J. T., and Strominger, J. L., *Science*, **125**, 99 (1957).

[11] Mitchell, P., and Moyle, J., *J. Gen. Microbiol.*, **5**, 981 (1951).

[12] Viscontini, M., Hoch, D., and Karrer, P., *Helv. Chim. Acta*, **38**, 642 (1955).

[13] Baddiley, J., Buchanan, J. G., and Carss, B., *J. Chem. Soc.*, 1869 (1957).

[14] Isherwood, F. A., Chen, Y. T., and Mapson, L. W., *Biochem. J.*, **56**, 54 (1954).

RESIDUAL BODIES OF SEMINIFEROUS TUBULES OF THE RAT

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JUST before sperms pass down the seminiferous tubules of the rat and various other mammals, they each cast off a small mass of material to which Regaud[1] gave the name "residual body". We have been investigating the formation, composition and fate of residual bodies with the view of determining their function. Modern histochemical and cytological techniques and both light and electron microscopy have been employed.

Light Microscope Observations

Evidence was obtained first which strongly suggested that residual bodies are of composite origin and structure. To clarify this problem, composite staining techniques of the kind described by Lacy[2] were utilized. Tissue was fixed according to the schedule given by Baker[3] and embedded in gelatine. Sections 3μ thick were affixed to gelatinized slides, and (*a*) impregnated with silver to show mitochondria[2], (*b*) coloured with sudan black *B* to show lipids, and (*c*) stained with pyronin-methyl green[4] to demonstrate basophilic material. The silver technique also revealed the Golgi remnant.

Within spermatids which had started to elongate we observed mitochondria, small lipoidal bodies, very fine basophilic granules and Golgi remnant. In older spermatids, with their elongate nuclei lying near the tubule lumen, we observed scattered mitochondria (distinct from those forming the mid-piece). Also present were lipoidal bodies generally of larger size than seen in younger spermatids, and aggregating to form mulberry-shaped clusters. Basophilic granules, less numerous but larger than in younger spermatids, and Golgi remnant, also occurred. At a later stage

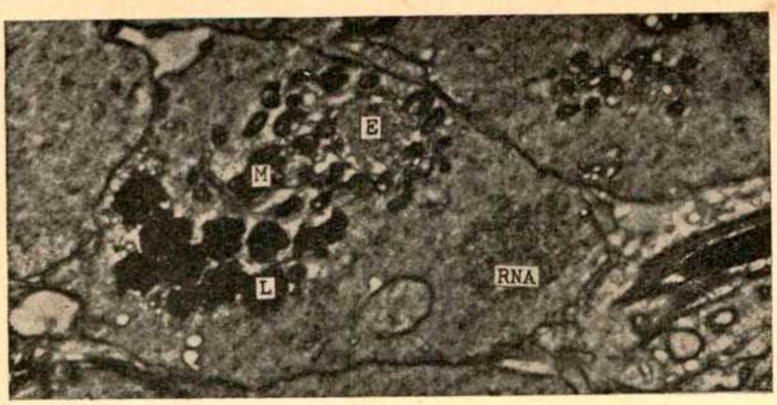

Fig. 1. Micrograph showing a late stage in the formation of a residual body. *E*, endoplasmic reticulum; *L*, lipoidal body; *M*, mitochondrion; *RNA*, aggregate of particles containing ribonucleic acid. (× *c*. 7,300)

in spermatid development all the above-mentioned inclusions had concentrated within a small lobe of cytoplasm near the base of the nucleus. Just before the mature spermatid is shed, this lobe of cytoplasm is cast off and becomes spheroidal in shape. The spheroidal bodies which arise in this way clearly correspond to the residual bodies of Regaud. Each residual body is bounded by a membrane derived from the cell membrane of the corresponding mature spermatid. Within, and close to, the limiting membrane lie two or three small groups of granular mitochondria, several lipoidal bodies (sometimes arranged in crescent fashion) and Golgi remnant. The greater part of each residual body is occupied by a comparatively large, eccentrically placed mass of strongly basophilic material.

Soon after the sperms have been shed the residual bodies migrate peripherally. As precisely as could be determined by light microscopy, this appeared to be due to phagocytosis by Sertoli cells. Afterwards, the residual bodies come to lie close to Sertoli nuclei at the border of the tubule.

Changes occur within the residual bodies both during their peripheral migration and while they are at the periphery of the tubule. The first sign of these changes is the appearance of minute vesicles about $0{\cdot}3\mu$ in diameter which form along the edges of the basophilic material. During their movement towards the periphery the residual bodies become reduced in size, their diameter decreasing from about 10μ to 5μ. Finally, there is a loss in basophilia and then all that can be seen is the limiting membrane, some mitochondria and lipoidal bodies, and the Golgi remnant. After this stage it is impossible to identify the residual bodies with any certainty. However, accompanying and following upon the 'end' stage, lipoidal bodies of about the same size as the residual bodies, and in the same general location, appear within the Sertoli cells. We have studied the residual bodies at this time to see if they become converted into the lipoidal bodies described above. What may be transitional stages have, in fact, been observed, but only very rarely.

Histochemical tests have shown that the basophilic material referred to above consists of, or contains, ribonucleic acid. The lipoidal bodies which occur within spermatid cytoplasm, and form part of the residual bodies, do not respond positively to Baker's[5] acid hæmatin test for phospholipins nor to Schultz's[6] test for cholesterol. The same negative responses for both tests are also given by the lipoidal bodies within Sertoli cells.

Electron Microscope Observations

Tissue was fixed in 1 per cent osmium tetroxide buffered to *p*H 7·3[7]. It was then embedded in a 1 : 3 mixture of *n*-methyl and *n*-butyl methacrylate, sectioned with a glass knife and examined in a Siemen's Elmiskop I*a*. Due to the comparatively small size of the residual bodies and the fact that they occur only under certain physiological conditions a great deal of material has had to be examined to find even the more important stages referred to above.

Observations made by electron microscopy are in accord with those made by light microscopy. In addition, finer details have been seen. During late formative stages (Fig. 1) the mitochondria are irregular in shape and characteristically cluster around a local concentration of endoplasmic reticulum. Adjacent to these elements is a group of osmiophilic granules which correspond to the lipoidal bodies seen under the light microscope. The Golgi remnant consists of a few paired membranes in parallel arrangement and aggregates of many small vesicles enclosed by two or more membranes. Near the inclusions just described occur one or two particulate masses, spheroidal in general outline and corresponding to the ribonucleic acid granules seen by light microscopy. At a later stage in the formation of the residual bodies the mitochondria are either greatly elongated and constricted in the middle (as though in a process of division) or are small, dense and spheroidal. The endoplasmic reticulum appears to consist of membranes delimiting vacuoles of various sizes. The basophilic material consists of one large mass of fine particles.

Studies by electron microscopy have confirmed quite definitely that the residual bodies are phago-

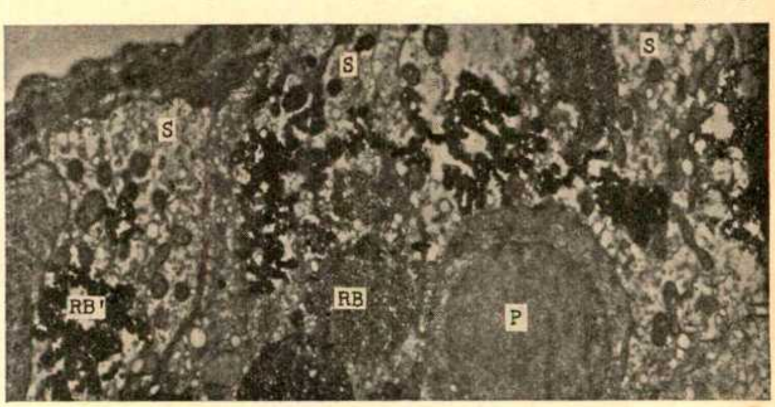

Fig. 2. Micrograph showing residual bodies within Sertoli cells at the border of a tubule. Some of the residual bodies (*RB*) are comparatively intact. Others have been largely absorbed and appear irregular in shape (*RB'*). *P*, primary spermatocyte; *S*, Sertoli cell. (× *c*. 7,300)

cytosed by the Sertoli cells Within any one Sertoli cell, even in ultra-thin sections, we have observed up to six residual bodies Each residual body is enclosed by a variable number (1–4) of fine membranes When the body reaches the edge of the tubule the limiting membranes are no longer continuous Residual bodies at the periphery contain the same basic constituents as those seen in the last stages of their formation in the tubule lumena Later, the basophilic material and various other components are absorbed until all that remains is an irregular-shaped body which is intensely osmiophilic and presumably lipoidal (Fig 2) About this time a peripheral ring of lipid can be demonstrated in Sertoli cells by the use of appropriate light microscopical techniques

When the residual bodies come to lie close to the Sertoli nuclei (adjacent to the tubule tissue) changes occur both within the Sertoli cytoplasm and in germ cells Within the Sertoli cells appears the peripheral ring of lipid mentioned above Mitochondria either increase in number or become concentrated peripherally The cytoplasmic matrix (as seen under the electron microscope) becomes very dense The young spermatids start to elongate and become more deeply enclosed by Sertoli cytoplasm There is an increase in chromatin content of the nuclei of type *B* spermatogonia It is possible that the residual bodies produce in the Sertoli cells some influence that may serve to trigger off the changes in the germ cells as reported above The residual bodies would then be responsible for the local control of spermatogenesis This is now being investigated further

We are grateful to the Wellcome Trust for a grant to purchase an electron microscope and to St Bartholomew's Hospital and Medical College for further financial help

[1] Regaud, C , *Arch Anat Micro* **4**, 101 (1901)
[2] Lacy, D , *J Roy Micro Soc* , **73**, 201 (1954)
[3] Baker, J R , *Quart J Micro Sci* , **90**, 293 (1949)
[4] Brachet, J , *Arch Biol* (Paris), **53**, 207 (1942)
[5] Baker, J R , *Quart J Micro Sci* , **88**, 463 (1947)
[6] Schultz, A , *Centralb Allg Path u Path Anat* , **35**, 314 (1924)
[7] Palade, G E , *J Exp Med* , **95**, 285 (1952)

GROWTH RESPONSES TO SELENIUM IN LAMBS

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UNTIL recently, selenium as a dietary constituent was regarded as of significance only when it occurred in excess of certain well-defined limits In selenium poisoning areas, about 5 p p m in herbage is considered to be the tolerance limit for livestock[1] It has now been shown[2–5] that selenium in organic and inorganic form has high protective powers against necrotic liver degeneration in the rat and mouse, and exudative diathesis in the chick fed basal diets deficient in vitamin E and containing a high proportion of *Torula* yeast , protection being obtained respectively with 0 04 p p m and 0 1 p p m of selenium in the ration It has been shown also in the chick that selenium is a required nutrient necessary for normal growth as well as for the prevention of exudative diathesis[6]

So far as large animals are concerned, there is evidence to indicate that sodium selenite fed to pregnant ewes at the rate of 0 1 p p m of selenium in the ration will protect their lambs against muscular dystrophy (white muscle disease)[7,8]

Furthermore, trials conducted in the South Island of New Zealand[9] suggest a protective action of selenium when given to the lambs themselves, in naturally occurring outbreaks of a type of muscular dystrophy affecting young lambs

Arising from the idea that subclinical muscular dystrophy might be one of the factors responsible for the slow growth-rate of weaned and unweaned lambs commonly observed in the South Island—a condition known locally as 'ill-thrift'—we commenced trials to investigate the possible effects of selenium supplements on the growth-rate of various classes of lambs on the College farms This communication records the observations made to date

All lambs were individually identified with ear-tags, divided at random into treatment and control groups, and weighed at intervals of 2–3 weeks Selenium was given as sodium selenate by subcutaneous injection in sterile water at the rate of 1 0 mgm selenium every 7–10 days Lambing commenced about the beginning of August, and weaning occurred in the first week of December

The first three trials involved pure-bred Romney, Border Leicester and Corriedale ram and ewe lambs reared on the College home farm The fourth trial was carried out on Corriedale wether lambs brought on to the College farm from the same farm on which the fifth trial was conducted (Ashley Dene farm)

Mean live weights and gains are set out in Table 1, with the numbers of lambs in each group given in brackets

Table 1 MEAN LIVE WEIGHTS AND GAINS (LB)

Trial 1	Romneys			
	Date	9 10 58	22 1 59	Gain
	Selenium	30 5 (94)	69 4	38 9
	Control	31 5 (88)	66 3	34 8
	Difference in 105 days			4 1**
Trial 2	Border Leicesters			
	Date	19 10 58	22 1 59	
	Selenium	51 2 (49)	79 2	28 0
	Control	50 3 (47)	71 9	21 6
	Difference in 95 days			6 4**
Trial 3	Corriedales			
	Date	21 11 58	22 1 59	
	Selenium	46 6 (61)	63 1	16 5
	Control	47 4 (59)	60 9	13 5
	Difference in 62 days			3 0**
Trial 4	Corriedale wethers			
	Date	11 11 58	12 2 59	
	Selenium	52 2 (20)	74 5	22 3
	Control	52 2 (20)	67 8	15 6
	Difference in 93 days			6 7**
Trial 5	Corriedale (mixed sex)			
	Date	3 11 58	2 2 59	
	Selenium	40 6 (23)	78 3	37 7
	Control	41 6 (21)	68 6	27 0
	Difference in 91 days			10 7**

** Significant at 1 0 per cent level

Analysis of variance shows that the differences in gains in live weight are highly significant ($P < 0\ 01$) in all trials The magnitude of these responses varies considerably, being greater in general in the lambs from the Ashley Dene farm The response is rapid, evidence of increased growth being observable in all groups in 2–3 weeks after treatment commenced.

Further, it appears to be a continuing one, although the duration of some of the trials is obviously short

Explanation of the mode of action of selenium in producing a growth response under these conditions must at the present time be rather speculative There can be little doubt now that traces of selenium are required by the animal for normal metabolism, that vitamin E and selenium are interrelated in their metabolic functions, and that vitamin E cannot completely replace the need for selenium The growth responses in lambs may therefore be taken as an indication of a specific selenium deficiency, one manifestation of which is a slowing up of growth, and another a predisposition to muscular dystrophy and possibly other conditions in which the metabolism of vitamin E is involved

This concept is in conformity with the known distribution of naturally occurring outbreaks of exudative diathesis in chicks and white muscle disease in lambs[10], both of which, in New Zealand, are almost entirely restricted to the South Island

In this respect it is of interest to note that the groups of lambs giving the greatest response (trials 4 and 5) came from flocks in which losses from white muscle disease had occurred earlier in the season before these trials commenced (4 out of 600 for trial 4 and 7 out of 51 in trial 5)

At the other extreme, in the pure-bred lambs on the College farm, only one death occurred from white muscle disease ; there were no other signs of the disease in the 580 lambs born this season, nor has there ever been any history of the disease on this farm Selenium responses have therefore been obtained, not only in lambs from areas where white muscle disease is common, but also where it has been extremely rare

On the other hand, the College farm has had a history of so-called 'ill-thrift' of varying degrees of severity over the past three years Just what part, if any, selenium deficiency plays in the 'ill-thrift' syndrome in this area is not as yet clear That it may be a factor of some importance is indicated by the data presented in these trials

This is a preliminary report only and final results will be published elsewhere

[1] Garner, R J , "Veterinary Toxicology" (Baillière, Tindall and Cox, London, 1957)

[2] Schwarz, K , and Foltz, C M , *J Amer Chem Soc* , **79**, 3292 (1957)

[3] Schwarz, K , Bieri, J C , Briggs, G M , and Scott, M L , *Proc Soc Exp Biol Med* , 95, 621 (1957)

[4] Patterson, E L , Milstrey, R , and Stokstad, E L R , *Proc Soc Exp Biol Med* , 95, 617 (1957)

[5] Dam, H , Nielsen, G K , Prange, I , and Sondergaard, E , *Experientia*, **13**, 493 (1957) , *Nutr Abst Rev* , **28**, 762 (1958)

[6] Nesheim, M C , and Scott, M L , *J Nutr* , **65**, 601 (1958)

[7] Muth, O H , Oldfield, J E , Remmert, L F , and Schubert, J R , *Science*, **28**, 1090 (1958)

[8] Procter, J F , Hogue, D E , and Warner, R G , *J Anim Sci* , **17**, 1183 (1958)

[9] Hartley, W J , Grant, A , and Drake, C , Wallaceville Animal Research Station, N Z (personal communication)

[10] Hartley, W J , and Dodd, D C , *N Z Vet J* , **5**, 61 (1957)

CARBOHYDRATE—AMINO-ACID INTER-RELATIONS IN BRAIN CORTEX *IN VITRO*

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IT is now well known that when radioactive glucose is metabolized by brain cortex *in vitro*, radioactive amino-acids are formed[1–5] A mince of the brain of one-day-old mice when incubated with glucose uniformly labelled with carbon-14 incorporates radioactivity in all amino-acids of brain protein with the exception of threonine[1] Rat brain cortex slices can convert ^{14}C-glucose into labelled glutamic, aspartic and γ-aminobutyric acids[3] When ^{14}C-glucose is injected intraperitoneally into one-day-old mice, radioactivity is found in aspartic and glutamic acids and in alanine in the brain proteins[3] It is evident that glucose, during its normal metabolism in the brain, produces intermediates—presumably the α-ketonic acids—that undergo conversion to amino-acids largely at the expense of organic nitrogen already available in the brain cell Such amino-acids must play a part not only in the various biosynthetic operations of the nerve cell but also in the maintenance of ionic balance in the cell It is therefore of importance to understand more fully than is known at present the precise relations existing between sugars and amino-acids in the brain, and the manner in which these relations may be affected by substances that influence brain metabolism Among such substances are potassium ions, which have long been known to exert profound effects on the metabolism of nerve cells Cationic balance is a factor of fundamental importance for the metabolism of brain, both aerobically[6] and anaerobically[7]

We have therefore carried out experiments to ascertain the effects, on the formation of amino-acids from glucose in the brain cortex *in vitro*, of those concentrations of potassium ions that produce optimal stimulation of respiration, of a neurotropic drug such as amytal and of a respiratory inhibitor such as sodium malonate The experiments have been carried out not only to throw more light on the mode of action of these substances but also to indicate the importance of the consideration of the amino-acids as part of the over-all metabolism of sugars in the nervous system

The experimental work was carried out with the conventional Warburg manometric apparatus Slices of rat brain cortex weighing approximately 90 mgm were incubated in a medium of the following composition sodium chloride, 128 m*M* , potassium chloride, 5 m*M* , calcium chloride, 3 6 m*M* , magnesium sulphate, 1 3 m*M* , disodium hydrogen phosphate, 10 m*M* brought to *p*H 7 4 with *N* hydrochloric acid The final volume was 1 0 ml. and each flask contained 5 m*M* glucose uniformly labelled with carbon-14 with an activity of 10^6 counts/min when counted on aluminium planchets at infinite thinness 0 1 ml. of 20 per cent potassium hydroxide was used as carbon dioxide absorbent Incubations were carried out in oxygen at 37° C for 1 hr , after which the tissue slices were homogenized in 8 0 ml of 80 per cent ethanol, centrifuged and the supernatant evaporated at 30° C in a current of air The dried extract was dissolved in 0 5 ml of water and 400 µl was chromatographed two-dimensionally on Whatman No 1 paper The solvents used were *sec* butanol/90 per cent formic acid/water (70 11 17 v/v/v) for the first phase, and phenol/water/ammonia (1 lb phenol 110 ml water 1 7 ml ammonia, spec grav. 0 88) for the second phase

The radioactive spots were localized by radioautography and the radioactivities of the spots were measured quantitatively using a 'Tracerlab' counter with a mica window 28 mm in diameter and thickness 1 5–1 8/cm ^{2} Activities were corrected for background The counting efficiency by this method was calculated to be 16 8 per cent

All results are expressed as counts per minute for 100 mgm of wet-weight tissue

Effects of Potassium Ions on Amino-acid Formation from Glucose and Fructose

The stimulating effects of potassium ions at 105 m*M* (preferably expressed as meq /litre (milliequivalents/litre)) on brain respiration, shown many years ago by Dickens and Greville[8] and by Ashford and Dixon[9], take place with the identical substrates, glucose, pyruvate or lactate, which permit responses to applied electrical pulses The potassium effect has many of the metabolic characteristics of brain tissue in the excited state It is suppressed by low concentrations of narcotics that have no demonstrable effects on the unstimulated respiration in the presence of glucose, which is quantitatively the most important metabolic fuel of the brain[10,11] and of ganglia[12] The narcotic suppression of potassium stimulation of brain respiration applies not only to central narcotics[13] but also to local anæsthetics[14], to chlorpromazine, alcohols and aldehydes[15,16] and to the newer depressants of the glutarimide type, and focuses interest on the mechanism of potassium stimulation of neurone respiration This stimulation seems greatly to resemble that brought about by oscillating electrical pulses[17,18], which may produce their effects by ionic displacements, for example, of potassium, calcium or sodium All the evidence points, in fact, to the similarity in many respects of the biochemical effects of electrical stimulation of the brain cortex slice with those due to the presence, in the incubation medium, of potassium ions at 0 1 molar concentration Brain homogenates or minces are, as is well known, unresponsive to either forms of activation Presumably in the conscious animal such stimulation operates by the action of sensory impulses, and high sensitivity to narcotics of the metabolic activity of the stimulated brain cell ensues

The potassium stimulation of brain respiration is highly sensitive to malonate, whereas unstimulated brain respiration is but little affected by malonate[19,20] It is evident[6,16] that potassium ions activate the citric acid cycle involved in glucose oxidation in the brain or a pace-making step closely associated with it

Results showing the effects of the addition of 105 m*M* potassium chloride solution to the incubation medium on amino-acid formation in rat brain cortex slices are shown in Table 1 It will be seen that in a normal physiological medium containing 5 m*M* potassium ions there is a labelling of glutamic acid, aspartic acid, glutamine, alanine and γ-aminobutyric acid in the presence of glucose and of fructose both uniformly labelled with carbon-14 The labelling of glutamic acid, with both sugars, is highest among the amino-acids investigated, aspartic acid showing the next highest activity It is noteworthy that the labelling of aspartic acid, on incubation with uniformly labelled fructose. greatly exceeds that of aspartic acid found after incubation with uniformly labelled glucose

Table 1 EFFECTS OF 0 1 *M* POTASSIUM CHLORIDE ON AMINO-ACID PRODUCTION FROM GLUCOSE AND FRUCTOSE UNIFORMLY LABELLED WITH CARBON-14 IN SLICES OF RAT BRAIN CORTEX

Substrate concentration, 5 m*M* (10^6 counts/min), incubation time, 60 min , temperature, 37° C , aerobic All values are expressed as counts/min /100 mgm wet tissue/10^6 counts/min uniformly labelled substrate per vessel

Amino-acid formed	Glucose-U-^{14}C		Fructose-U-^{14}C	
	5 m*M* K$^+$	105 m*M* K$^+$	5 m*M* K$^+$	105 m*M* K$^+$
Glutamic acid	5,057 ±358	5,516 ±475	4,784 ±307	942 ± 21
Aspartic acid	1,318 ±164	1,183 ±185	2,159 ±122	2,127 ±104
Glutamine	1,289 ±112	2,397 ±209	(*)	(*)
Alanine	657 ± 60	794 ± 49	374 ± 63	224 ± 24
γ-Amino-butyric acid	966 ±142	1,491 ±164	739 ± 22	271 ± 10

All values are given with mean standard errors

* Glutamine could not be counted, when fructose was used as substrate, as the fructose spot overlapped that of glutamine

The most important quantitative effect of the presence of 105 m*M* potassium ions, which increases the respiration of brain cortex slices in the presence of glucose by almost 100 per cent, is to bring about a large increase in the labelling of glutamine (nearly 100 per cent) and of γ-aminobutyric acid The total count of the labelled amino-acids in the presence of glucose uniformly labelled with carbon-14 is increased from 9,287 to 11,381 counts/min The labelling of glutamic acid or alanine is slightly increased whereas that of aspartic acid is slightly decreased

It may be noted that the ratios of radioactive glutamate, glutamine and γ-aminobutyrate found with potassium-stimulated rat brain-cortex slices in presence of glucose are 1 0 44 0 27 (Table 1), which approximate to the ratios of these amino-acids normally found in the adult rat brain cortex[31], namely, 1 0 43 0 17

As it is well known that glutamine is derived from glutamate in brain in a reaction involving adenosine triphosphate[21], the process bringing about the removal of free ammonium ions that are liberated during the functional activity of the brain[22], and that γ-aminobutyric acid is derived from glutamate by a decarboxylase normally present in the brain[23], we may consider that the net effect of exposing brain-cortex slices in presence of glucose, uniformly labelled with carbon-14, to 105 m*M* potassium ions, is to increase the total yield of glutamic acid, the excess over the normal appearing as both glutamine and γ-aminobutyric acid This phenomenon may be explained by the fact that the presence of 105 m*M* potassium ions accelerates the operation of the citric acid cycle in the brain, increasing the rate of turnover of intermediates, among which is α-keto-glutarate which, by transamination with intracellular amino-acids, forms glutamate and thence glutamine and γ-aminobutyric acid

Typical results given in Table 2 lead to the conclusion that the presence of potassium ions accelerates the conversion of pyruvate to acetyl-coenzyme *A* The results demonstrate that the presence of 105 m*M* potassium ions greatly increases the rate of oxidation in brain cortex of both pyruvate-1-^{14}C and pyruvate-2-^{14}C to carbon-14 dioxide, the latter process being much more inhibited by the presence of malonate than the former The fact that some inhibition

Table 2 COMPARISON OF THE EFFECTS OF 0 01 *M* SODIUM MALONATE AND 0 1 *M* POTASSIUM CHLORIDE ON OXIDATION OF PYRUVATE-1-^{14}C AND PYRUVATE-2-^{14}C BY SLICES OF RAT BRAIN CORTEX

Substrate concentration, 10 m*M* (10^5 counts/min), incubation time 60 min , temperature, 37° C , aerobic Carbon-14 dioxide evolved expressed as counts/min /mgm dry weight tissue/hr /10^6 counts/min substrate per vessel

Experimental conditions	Pyruvate-1-^{14}C		Pyruvate-2-^{14}C	
	5 m*M* K$^+$	105 m*M* K$^+$	5 m*M* K$^+$	105 m*M* K$^+$
Sodium pyruvate only	1,166	2,008	481	1,040
Sodium pyruvate + 0 01 *M* sodium malonate	903	1,342	258	336

of the former process by malonate occurs leads to the conclusion that part of the carbon-14 dioxide derived from pyruvate-1-^{14}C is formed after its fixation and metabolism by the citric acid cycle

Granting that the effect of the presence of 105 m*M* potassium ions is an increased rate of formation of acetyl-coenzyme *A*, it becomes at once apparent (see Fig 1) that the rate of formation of α-ketoglutarate (and thereby the rates of formation of glutamate, glutamine and γ-aminobutyrate) should be increased, whereas that of oxalacetate (and thereby aspartate) may not be increased, as its greater rate of formation is balanced by its greater rate of removal by condensation with the increased quantity of acetyl-coenzyme *A* that has become available

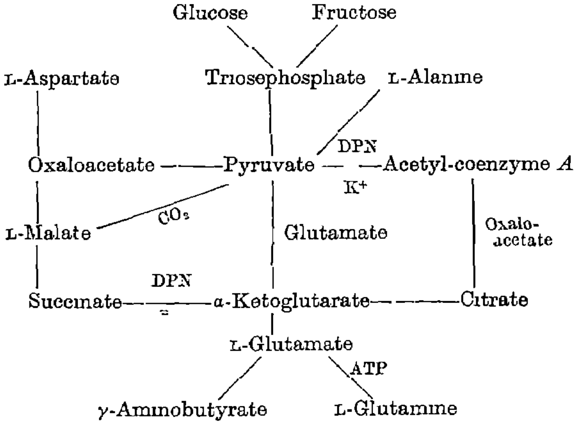

Fig 1

The conclusion that the major effect of increased potassium ions is to increase the velocity of formation of acetyl-coenzyme *A* from pyruvate in brain cortex makes it possible to understand the mode of action of potassium ions in affecting the formation of amino-acids from fructose uniformly labelled with carbon-14 It will be seen, in the results quoted in Table 1, that in the presence of the normal potassium ion concentration (5 m*M*), there is a marked increase of labelled aspartate and a marked decrease of labelled alanine as compared with the amounts of these amino-acids formed in the presence of glucose uniformly labelled with carbon-14 When the potassium ion concentration is increased to 105 m*M*, the outstanding effects are the large falls in the amounts of labelled glutamate and γ-aminobutyric acid Owing to experimental difficulties, when using fructose on paper chromatograms, it was not possible to make accurate assays of the radioactive glutamine formed

The significant factor to be taken into account in interpreting the results found with uniformly labelled fructose (Table 1) is the much lower affinity of fructose for brain hexokinase than that of glucose[24] The result of this lower affinity is a diminished availability of pyruvate in the brain cortex slices, under the experimental conditions quoted, a fact that accounts for the feeble anaerobic glycolysis exhibited by brain cortex in presence of fructose Sufficient pyruvate is available, however, to enable the citric acid cycle to operate and to yield a respiratory value of the same order as shown by glucose in presence of brain cortex The lack of availability of pyruvate, apart from that amount required for the citric acid cycle to operate, is also shown by the much lower ability of brain cortex slices to form lactic acid or to synthesize acetyl choline in presence of fructose as compared with that found in the presence of glucose[25] Although respiratory activities, and presumably, therefore, the amounts of available adenosine triphosphate, of brain cortex slices in the presence of glucose and fructose are approximately the same, the rate of formation of acetyl-coenzyme *A* in the presence of the former sugar is greater than in the presence of the latter

The lowered availability of pyruvate, in brain cortex slices in the presence of fructose uniformly labelled with carbon-14, results in there being less acetyl-coenzyme *A* available for condensation with oxalacetic acid formed during the operation of the citric acid cycle This in turn leads to more oxalacetic acid being available for transamination into aspartic acid than occurs with glucose On this interpretation, the larger yields of labelled aspartic acid found in the presence of uniformly labelled fructose than in the presence of uniformly labelled glucose is directly due to lack of available acetyl-coenzyme *A* for the acetylation of oxalacetic acid The lowered availability of pyruvic acid from uniformly labelled fructose is shown also by the diminished rate of formation of labelled alanine (Table 1) in the presence of this sugar

The effects of an increased concentration of potassium ions on amino-acid formation from fructose may also be understood The acceleration of conversion of pyruvate to acetyl-coenzyme *A* by the presence of 105 m*M* potassium ions leads to an increased rate of respiration, so that more of the limited pyruvate available is converted to carbon dioxide There is therefore less pyruvate available for conversion to amino-acids Experiment shows (Table 1) that a total count of 8,056 counts/min for the amino-acids investigated falls to 3,564 counts/min in the presence of 105 m*M* potassium ions

The limited amount of pyruvate, made available from fructose, leads ultimately to the formation of a smaller quantity of α-ketoglutarate than takes place with glucose, in spite of the increased rate of formation of acetyl-coenzyme *A* due to the presence of 105 m*M* potassium ions This in turn leads to smaller amounts, at equilibrium, of labelled glutamate and γ-aminobutyrate The quantity of labelled aspartate formed, however, remains approximately constant This occurs, presumably, because the malic acid enzyme that transforms pyruvate to malate with fixation of carbon dioxide, and thence to oxalacetate and aspartate, is operating optimally This process is already known to occur with retina[28] and with mouse brain[30]

It is therefore possible to obtain an understanding of the relations existing between glucose or fructose, and the amino-acids derived from these sugars in the brain, both in the presence of normal and high concentrations of potassium ions, on the basis of our present knowledge of the operations of the citric acid cycle in brain, of transaminating processes affecting the α-ketonic acids, and on the conclusion that the stimulating action of potassium is largely directed to the conversion of pyruvate into acetyl-coenzyme *A*.

The implications of these findings are considerable, for they indicate that cationic balance, by influencing the relative velocities of the neurochemical processes, affects the formation of substances, such as acetylcholine or γ-aminobutyric acid, which are now well known to be implicated in the electrophysiology of the nervous system.

Effects of Sodium Malonate on Glucose–Amino-Acid Inter-relations

In the presence of 10 m*M* sodium malonate, the respiration of brain cortex stimulated by potassium is inhibited to the level of the endogenous respiration, which is only slightly affected.

The effects of the addition of 10 m*M* sodium malonate on the formation of labelled amino-acids from glucose uniformly labelled with carbon-14 are shown in Table 3.

Table 3. INFLUENCE OF 0.01 *M* SODIUM MALONATE ON AMINO-ACID FORMATION FROM GLUCOSE UNIFORMLY LABELLED WITH CARBON-14 WITH AND WITHOUT 0.1 *M* POTASSIUM CHLORIDE

Experimental conditions as in Table 1. Results (counts/min./100 mgm. wet tissue/10^6 counts/min. glucose) are the mean values of three sets of experimental results

Amino-acid formed	5 m*M* K^+ + 0.01 *M* malonate	105 m*M* K^+ + 0.01 *M* malonate
Glutamic acid	1,990	995
Aspartic acid	328	583
Glutamine	361	72
Alanine	133	60
γ-Aminobutyric acid	522	194

The most noteworthy effect of the malonate is the decrease in labelling of all the amino-acids; a total amino-acid count of 9,287 counts/min. is reduced by malonate to 3,334 counts/min. The percentage decrease effected by malonate is greater in the presence of 105 m*M* potassium ions. The total count of 11,381 counts/min. found with the high potassium ion concentration is reduced to 1,904 counts/min. when the malonate is added. Thus not only is the potassium stimulation of brain respiration abolished by malonate[13], but also its stimulation of amino-acid labelling in the presence of radioactive glucose. The suppression of respiration is reflected by the lowered availability of pyruvate, and hence in the diminished production of labelled alanine and of α-ketoglutarate, and hence in the diminished rates of formation of glutamate, glutamine and γ-aminobutyric acid.

Effects of Sodium Amytal on Amino-acid Formation from Glucose

In accordance with the conclusion by Michaelis and Quastel[27] that a narcotic, such as chloretone, suppresses specifically at low concentrations the activity of a process playing an intermediate part in tissue respiration between a flavoprotein involving diphosphopyridine nucleotide, and cytochrome oxidase, it has been shown[28] that amytal (5-ethyl-5-*iso*amyl barbiturate) is a highly effective inhibitor of the oxidation of reduced diphosphopyridine nucleotide and its associated phosphorylations.

An effect, therefore, of the addition of a narcotic, such as amytal, to respiring tissue is to bring about an increase in the ratio of reduced diphosphopyridine nucleotide to diphosphopyridine nucleotide in the cell. The change in this ratio, or the diminished availability of diphosphopyridine nucleotide for its various linked reactions in cell metabolism, has a variety of consequences. One obvious result is an increase in the rate of reduction of pyruvate, derived from aerobic breakdown of glucose in the brain cell, to lactate, so that an increased aerobic glycolysis in the presence of the narcotic takes place. This is a well-known phenomenon[29]. Other results, due both to the changed velocities of the diphosphopyridine nucleotide-linked reactions and to the diminished availability of adenosine triphosphate consequent upon the suppression of oxidation of reduced diphosphopyridine nucleotide, may be expected to take place.

The effects of the addition of 0.5 m*M* sodium amytal on amino-acids formed from glucose, uniformly labelled with carbon-14, in the presence and absence of 105 m*M* potassium ions are shown in Table 4. At this concentration, amytal exerts only a small inhibitory effect on the oxidation of glucose by the unstimulated brain cortex slices but almost a complete suppression of the potassium-stimulated respiration of brain cortex in the presence of glucose[6]. The results (Table 4) demonstrate these effects.

Table 4. INFLUENCE OF 0.5 m*M* SODIUM AMYTAL ON AMINO-ACID FORMATION FROM GLUCOSE UNIFORMLY LABELLED WITH CARBON-14 WITH AND WITHOUT 0.1 *M* POTASSIUM CHLORIDE

Experimental conditions as in Table 1

Amino-acid formed	5 m*M* K^+ + glucose-U-^{14}C 0.5 m*M* amytal	105 m*M* K^+ + glucose-U-^{14}C 0.5 m*M* amytal
Glutamic acid	5,793 ± 335	6,761 ± 450
Aspartic acid	1,002 ± 65	661 ± 51
Glutamine	1,095 ± 80	111 ± 10
Alanine	1,104 ± 70	386 ± 36
γ-Aminobutyric acid	1,798 ± 45	1,479 ± 123

(*a*) In normal physiological media (5 m*M* potassium ions) the presence of 0.5 m*M* amytal produces a marked increase in the rates of formation of labelled γ-aminobutyric acid and alanine, with relatively small changes in the rates of appearance of labelled glutamate, aspartate and glumatine.

(*b*) In the presence of 105 m*M* potassium ions and 0.5 m*M* amytal, there is a very large fall in the rate of formation of labelled glutamine from 2,397 counts/min. (Table 1) to 111 counts/min. (Table 4). There is a fall also in the rate of formation of labelled alanine and aspartic acid and a rise in that of glutamic acid.

The results may be explained in the following manner.

(1) With the unstimulated slice of brain cortex, the amytal brings about a diminution of available diphosphopyridine nucleotide, so that less pyruvate is oxidized to acetyl-coenzyme *A* and less α-ketoglutarate is converted to succinate. There is not only, therefore, an increased rate of conversion of pyruvate to lactate but also an increased rate of conversion, by transamination, of labelled pyruvate to alanine and of labelled α-ketoglutarate to glutamate. The latter reaction is reflected in an increased rate of formation of labelled γ-aminobutyrate. The rate of formation of glutamine is not increased; it is in fact decreased, presumably because the suppression of oxidation of reduced diphosphopyridine nucleotide, leading to a diminished synthesis of adenosine tri-

phosphate, results in a diminished amount of the latter being available for synthesis of glutamine

(2) With the stimulated slices of brain cortex, in which the oxidation of pyruvate by diphosphopyridine nucleotide to acetyl-coenzyme *A* is greatly enhanced, the effect of the presence of the narcotic is to suppress this oxidation owing to the lowered availability of diphosphopyridine nucleotide The increase of reduced diphosphopyridine nucleotide leads to an increased rate of formation of lactate (that is, increased aerobic glycolysis), this process taking place partly at the expense of pyruvate that would otherwise be transformed to alanine A similar suppression of oxidation of α-ketoglutarate leads to enhanced labelling of glutamate The synthesis, however, of glutamine from glutamate is almost entirely blocked by the narcotic, by its suppression of synthesis of adenosine triphosphate normally coupled with the oxidation of reduced diphosphopyridine nucleotide

It is evident that the processes controlling glucose – amino-acid inter-relations in both the unstimulated and stimulated slice of brain cortex and in the absence or presence of a narcotic such as amytal may be interpreted satisfactorily on the basis of the conclusions that the stimulation consists of an acceleration of the conversion of pyruvate to acetyl-coenzyme *A* and that the narcotic brings about a suppression of endogenous oxidation of diphosphopyridine nucleotide by cytochrome oxidase and its associated phosphorylations

Summary

(1) Glucose and fructose, both uniformly labelled with carbon-14, in the presence of slices of rat brain cortex, are partly converted to radioactive glutamic acid, glutamine, γ-aminobutyric acid, aspartic acid and alanine The yields, and relative proportions, of these amino-acids found with the uniformly labelled glucose differ considerably from those found with uniformly labelled fructose An outstanding difference is the large yield of labelled aspartic acid found with fructose as compared with that from glucose

(2) When brain cortex respiration in the presence of glucose or fructose is stimulated by the addition of 105 m*M* potassium ions, large changes take place in the yields and relative proportions of radioactive amino-acids With glucose, the effect is greatly to increase the yield of glutamine and γ-aminobutyric acid With fructose, the effect is greatly to diminish the yield of labelled glutamate

(3) It is concluded, from the effects of the addition of 105 m*M* potassium ions on the formation of carbon-14 dioxide from pyruvate-1-^{14}C and pyruvate-2-^{14}C, and on the relative inhibitory effects of malonate on these processes, that the stimulating effect of addition of potassium ions on the respiration of brain cortex is largely directed to an acceleration of a pace-making step, the conversion of pyruvate to acetyl-coenzyme *A*

(4) The presence of malonate, which abolishes the potassium ion stimulation of respiration of brain cortex, brings about a greatly diminished labelling of all amino-acids derived from glucose, uniformly labelled with carbon-14, and in the presence of added potassium ions almost completely blocks the formation of alanine, glutamine, and γ-aminobutyric acid

These results can be satisfactorily explained on the basis of the conclusions that the amino-acids are derived from glucose by transamination of the α-ketonic acids derived during the operation of the citric acid cycle and that the potassium ion stimulation of the metabolism of brain cortex is due to it acceleration of the oxidation of pyruvate to acetyl-coenzyme *A*

(5) The presence of the narcotic, 0 5 m*M* sodium amytal, produces, with the unstimulated brain cortex slice, a marked increase in the yield from glucose uniformly labelled with carbon-14, of labelled γ-aminobutyric acid and alanine, with relatively small changes in the yields of labelled glutamate, aspartate and glutamine With the stimulated brain cortex slice (that is, with 105 m*M* potassium ions) the narcotic at small concentrations brings about a very large fall in the yield of labelled glutamine, falls in the yields of labelled alanine and aspartic acid and a rise in the yield of labelled glutamic acid These results may be adequately explained on the basis of the conclusions given above, together with the conclusion that the main effect of the narcotic is to suppress the oxidation of reduced diphosphopyridine nucleotide by cytochrome oxidase and its associated phosphorylations

We acknowledge, with gratitude, a grant-in-aid from the National Research Council of Canada which made this work possible

[1] Sky-Peck, H H , Pearson, H E , and Visser, D W , *J Biol Chem* 223, 1033 (1956)

[2] Winzler, R J , Moldave, K , Rafelson, jun , M E , and Pearson H E , *J Biol Chem* , 199, 485 (1952)

[3] Beloff-Chain, A , Catanzaro, R , Chain, E B , Masi, I , and Pocchiar F , *Proc Roy Soc* , B, 144, 22 (1955)

[4] Tsukada, Y , Nagata, Y , and Takagaki, G , *Proc Japan Acad* , 3 510 (1957)

[5] Geiger, A , *Physiol Rev* , 38, 1 (1958)

[6] Quastel, J H , Proc Fourth Int Cong Biochem , Vienna, 3 (Pe gamon Press, 1958)

[7] Adams, D H , and Quastel, J H , *Proc Roy Soc* , B, 145, 472 (1956

[8] Dickens, F , and Greville, G D , *Biochem J* , 29, 1468 (1935)

[9] Ashford, C A , and Dixon, K C , *Biochem J* , 29, 157 (1935)

[10] Kety, S S , in "Metabolism of the Nervous System", 221 (Pergamo Press, London, 1957)

[11] Himwich, H E , "Brain Metabolism and Cerebral Disorders (Williams and Wilkins, Baltimore, 1951)

[12] Larrabee, M G , and Horowicz, P , "Molecular Structure and Func tional Activity of Nerve Cells", 84 (Amer Inst Biol Sci , Wash ington, D C , 1956)

[13] Ghosh, J J , and Quastel, J H , *Nature*, 174, 28 (1954)

[14] Geddes, I C , and Quastel, J H , *Anaesthesiology*, 17, 666 (1956)

[15] Lindan, O , Quastel, J H , and Sved, S , *Canad J Biochem Physiol* 35, 1135 and 1145 (1957)

[16] Beer, C T , and Quastel, J H , *Canad J Biochem Physiol* , 3 531 and 543 (1958) Quastel, J H , and Parmar, S S , Proc Int Symp Enz Chem Tokyo, 510 (Maruzen, Tokyo, 1958)

[17] McIlwain, H , *Biochem J* , 52, 289 (1952) , 53, 403 (1953) Quaste J H , Proc Third Int Cong Biochem Brussels, 496 (1956)

[18] Wollenberger, A , *Biochem J* , 61, 68, 77 (1955)

[19] Kimura, Y , and Niva, T , *Nature*, 171, 881 (1953) Tsukada, Y and Takaguchi, O , *ibid* , 175, 725 (1955)

[20] Takagaki, G , Hirano, S , and Tsukada, Y , *J Biochem* (Japan), 4 41 (1958)

[21] Krebs, H A , *Biochem J* , 29, 1951 (1935) Elliot, W H , *ibid* , 4 1 (1951) Speck, J F , *J Biol Chem* , 179, 1405 (1949)

[22] Winterstein, H , and Hirschberg, E , *Biochem Z* , 167, 401 (1926 Richter, D , and Dawson, R M C , *J Biol Chem* , 176, 119 (1948) Vrba, R , *J Neurochem* , 1, 12 (1956)

[23] Roberts, E , and Frankel, S , *J Biol Chem* , 190, 505 (1951)

[24] Harpur, R P , and Quastel, J H , *Nature*, 164, 693 (1949) Wiebe haus, V D , and Lardy, H A , *Arch Biochem* , 21, 321 (1949) Meyerhof, O , *ibid* , 13, 485 (1947) Meyerhof, O , and Wilson J R , *ibid* , 19, 5002 (1949)

[25] Mann, P J G , Tennenbaum, M , and Quastel, J H , *Biochem J* 33, 1506 (1939)

[26] Crane, R K , and Ball, E G , *J Biol Chem* , 188, 819 (1951) , 18 269 (1951)

[27] Michaelis, M , and Quastel, J H , *Biochem J* , 35, 918 (1941)

[28] Ernster, L , Löw, H , and Lindberg, O , *Acta Chem Scand* , 9, 20 (1955) Ernster, L , Jalling, O , Low, H , and Lindberg, O *Exp Cell Res* , Supp 3, 124 (1955)

[29] Greig, M E , *J Pharmacol Exp Ther* , 91, 317 (1947) Rosenberg A J , Buchel, L , Etling, N , and Levi, J , *C R Acad Sci Pari* 230, 480 (1950) Webb, J L , and Elliott, K A C , *J Pharmaco Exp Ther* , 103, 24 (1951)

[30] Moldave, K , Winzler, R J , and Pearson, H E , *J Biol Chem* 200, 357 (1953)

[31] Berl, S , and Waelsch, H , *J Neurochem* , 3, 161 (1958)

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APPLICATIONS are invited for the following appointments on or before the dates mentioned

LECTURER or ASSISTANT LECTURER IN PURE MATHEMATICS—The Deputy Registrar, The University, Edgbaston, Birmingham 15 (September 22)

READER or SENIOR LECTURER IN MECHANICAL ENGINEERING at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (October 2)

SENIOR LECTURER or LECTURER IN MATHEMATICAL STATISTICS at, the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (October 3)

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LECTURER (with a university degree in mechanical engineering and experience of machine-shop practice) IN THE DEPARTMENT OF MECHANICAL ENGINEERING at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (October 31)

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REPORTS and other PUBLICATIONS

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Great Britain and Ireland

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Admiralty Tidal Handbook No 1 The Admiralty Semi-graphic Method of Harmonic Tidal Analysis (over a period of one month) Pp 72 (H D 505) (London Hydrographic Department, Admiralty, 1959) 21*s* net [225

Kent Incorporated Society for Promoting Experiments in Horticulture Annual Report of the East Malling Research Station, near Maidstone, Kent, 1st October 1957 to 30th September 1958 (Forty-sixth year) Pp xxvi+178+16 plates 17*s* 6*d* , 2 50 dollars Abstracts and Index to the Annual Research Reports 1913–1953, East Malling Research Station Pp vi+175 (East Malling East Malling Research Station, 1959 and 1957) [225

Lancashire Dynamo Holdings Limited Report 1958 Pp 16 (London Lancashire Dynamo Holdings, Ltd , 1959) [225

Macaulay Institute for Soil Research Collected Papers, Vol 5, 1955–1957 Edited by Miss A M B Geddes Pp 23+82 reprints Collected Papers, Supplementary Volume A, 1940–1957 Pp ii+4 papers (Craigiebuckler, Aberdeen Macaulay Institute for Soil Research, 1958) [225

Siemens Edison Swan, Ltd Application Report Transistor Sound Receiver SR2/2 Pp 20 (London Siemens Edison Swan, Ltd , 1958) [225

International Committee for Bird Preservation, British Section Annual Report for 1958 Pp 41 (London International Committee for Bird Preservation, British Section, c/o British Museum (Natural History), 1959) [225

John Innes Horticultural Institution Forty-ninth Annual Report, 1958 Pp 44 (Bayfordbury, Hertford John Innes Horticultural Institution, 1959) 3*s* [225

British Iron and Steel Research Association Annual Report 1958 Pp 154 (London British Iron and Steel Research Association, 1959) [225

Horizon, Vol 1, Summer Term, 1959 (A science magazine) Pp viii+36 (Cardiff University College, 1959) 1*s* 6*d* [225

Scottish Plant Breeding Station Report, 1959 Pp 96+1 plate (Pentlandfield, Roslin Scottish Society for Research in Plant-Breeding, 1959) [225

Smoking The Cancer Controversy—Some Attempts to Assess the Evidence By Sir Ronald A Fisher Pp 47 (Edinburgh and London Oliver and Boyd, Ltd , 1959) 2*s* 6*d* [225

Arthur D Little Research Institute Annual Report for 1958 Pp 34 (Inveresk, Midlothian Arthur D Little Research Institute, 1959) [225

Institute of Physics Notes for Authors a Guide for Contributors to the Institute's Journals and other Publications Revised edition Pp 36 (London Institute of Physics, 1959) 3*s* 6*d* [225

Government of Northern Ireland Ministry of Agriculture Leaflet No 67 The Cultivation of Vegetables Pp 22 Leaflet No 81 The Construction of Farm Dairying Buildings Pp 31 (Belfast Ministry of Agriculture, 1959) [225

Age and the Working Lives of Men an Attempt to Reduce the Statistical Evidence to its Practical Shape By F Le Gros Clark (Studies of Ageing Within the Conditions of Modern Industry) Pp 68 (London Nuffield Foundation, 1959) 3*s* net [225

National Institute of Oceanography Collected Reprints, Vol 6 Reprints Nos 210–247 (Wormley, near Godalming National Institute of Oceanography, 1958) [225

British Electrical and Allied Industries Research Association Technical Report E/T71 A Thermocouple Method of Studying Oxidation Reactions Photosensitised Oxidation of Cyclohexene By J C Robb and M Shahin Pp 16+9 figures 12*s* 6*d* Technical Report L/T370 Dielectric Effects of Flaws in Hydrogen Bonding By Dr Vera Daniel Pp 20+9 figures 15*s* Technical Report L/T372 Field Dependence of Mobility in Semiconductors By B V Paranjape Pp i+11 7*s* 6*d* (Leatherhead British Electrical and Allied Industries Research Association, 1958) [225

Department of Scientific and Industrial Research Forest Products Research 1958 Report of the Director of Forest Products Research Pp vi+64+8 plates (London H M Stationery Office, 1959) 5*s* net [225

Eighth Congress of the Universities of the Commonwealth, Montreal, September 1–5, 1958 Report of Proceedings Pp xxix+100 (London Association of Universities of the British Commonwealth, 1959) 12*s* 6*d* [225

Clean Air Year Book 1959 Pp 68 (London National Society for Clean Air, 1959) 2*s* [285

University of Glasgow Appointments Committee Report for the year ended 31st December, 1958 Pp 15 (Glasgow The University, 1959) [285

Tobacco Manufacturers' Standing Committee Research Papers, No 1 Statistics of Smoking Second edition Pp ii+81 (London Tobacco Manufacturers' Standing Committee, 1959) [285

Flora of Tropical East Africa Edited by C E Hubbard and E Milne-Redhead Leguminosæ, Subfamily Mimosoideæ By J P M Brenan Pp 173 (London Crown Agents for Oversea Governments and Administrations, 1959) 12*s* [46

Institution of Chemical Engineers Scheme for a Full-Time Course in Chemical Engineering Pp 16 (London Institution of Chemical Engineers, 1959) 2*s* [46

Planning, Vol 24, No 434 (1 June, 1959) Management and Underdeveloped Territories Pp 113–130 (London Political and Economic Planning, 1959) 2*s* 6*d* [46

Royal Institute of Chemistry Register of Fellows and Associates Pp xx+576 (London Royal Institute of Chemistry, 1958) [46

Grassland Research Institute Annual Report for 1957–58 (Experiments in Progress No 11) Pp 108 (Hurley, near Maidenhead Grassland Research Institute, 1959) 7*s* 6*d* [46

Management Development a Systematic Approach to the Provision of Supervisors and Managers By F I de la P Garforth Pp 72 (London Institute of Personnel Management, 1959) 15*s* 6*d* [46

The Transistor Era a Guide to Transistors and Associated Semiconductor Devices Pp 96 (London Heywood and Co , Ltd , 1959) 5*s* [46

Philosophical Transactions of the Royal Society of London Series B Biological Sciences No 692, Vol 242 (28 May, 1959) The Wealden Environment Anglo-Paris Basin By P Allen Pp 283–346 10*s* No 693, Vol 242 (28 May, 1959) Changes in the Chalk Heart-Urchin *Micraster* Interpreted in Relation to Living Forms By D Nichols Pp 347–437+plate 9 30*s* (London Royal Society, 1959) [46

Soviet Rubber Technology, No 1, June 1959 (English translation of *Kauchuk i Rezina*, No 1, Vol 18, January 1959) Pp 64 Annual subscription rates (Ordinary) U K £10 10*s* , Abroad 50 U S dollars or equivalent R A B R M Members and U K Non-profit making Institutions £5 5*s* (Shawbury, Shrewsbury Association of British Rubber Manufacturers, 1959 Obtainable from Maclaren and Sons, Ltd , 131 Great Suffolk Street, London, S E 1) [46

Elliott-Automation Limited Report and Accounts 1958. Pp 20 (London Elliott-Automation Limited, 1959) [46

Two Threats to Broadcasting Political and Commercial Control By H Carleton Greene (Translation of a speech made on behalf of the B B C to an association of German business men—the Wirtschaftsring, in Bad Schwalbach, 18 April) Pp 8 (Supplement No 3, Aeriel Vol 4, No 5) (London British Broadcasting Corporation, 1959) [96

Ciba (A R L), Limited Technical Notes, No 197 (May 1959) 'Araldite' Epoxy Resins for Foundry Patterns Pp 8 (Duxford Ciba (A R L), Limited, 1959) [96

City of Portsmouth College of Technology Management Studies, Session 1959–60 Pp 8 (Portsmouth College of Technology, 1959) [96

British Society for the Promotion of Vegetable Research Ninth Annual Report 1958 (Oct 1957–Sept 1958) Pp viii+55 (Wellesbourne, Warwick British Society for the Promotion of Vegetable Research, 1959) [96

Other Countries

National Academy of Sciences—National Research Council Bi-Annual Report of the Pacific Science Board, 1957–1958 Pp 71 (Washington, D C National Academy of Sciences—National Research Council, 1959) [225

Académie Royale de Belgique Classe des Sciences Mémoires Tome 31, Fascicule 2 Contribution à l'Étude de l'Algèbre des Applications Lineaires Continués d'un Espace Localement Convexe Séparé Théorie de Riesz—Théorie Spectrale Par André Deprit Pp 170 (Bruxelles Académie Royale de Belgique, 1959) 120 Belgian francs [225

Chicago Natural History Museum Fieldiana Botany Vol 30, No 2 Orchids of Peru By Charles Schweinfurth Pp vi+261–531 (Chicago Chicago Natural History Museum, 1959) 4 50 dollars [225

Cawthron Institute, Nelson, New Zealand Annual Report 1957–58 Pp 55 (Nelson Cawthron Institute, 1958) [225

National Academy of Sciences—National Research Council, 1957–1958 Pp iii+65 (Washington, D C National Research Council—National Academy of Sciences, 1959) [225

L'Auto-Immunisation en Pathologie Étude Expérimentale sur la Pathogénie des Glomérulonéphrites, des Encéphalomyelites et des Syndromes Hémolytiques Acquis Par Simone Stadtsbaeder (Thèse pour l'Agrégation de l'Enseignement Supérieur) Pp 185 (Bruxelles Éditions Arscia, 1959) [225

Studia Philosophica, Vol 18 Jahrbuch der Schweizerischen Philosophischen Gesellschaft Pp vii+248 (Basel Verlag fur Recht und Gesellschaft, 1958) [225

Journal of Nuclear Materials, Vol 1, No 1, (April 1959) Pp ii+112 Published quarterly Subscription rate (1 volume of 360 pages) 130*s* , 68 50 guilders, 18 dollars (Amsterdam North-Holland Publishing Company, 1959) [225

Report of the Trustees of the Australian Museum for the year ended 30th June, 1958 Pp 19 (Sydney Government Printer, 1959) [225

United States Department of the Interior Geological Survey Bulletin 1019–M Annotated Bibliography on the Geology of Selenium By Gwendolyn W Luttrell Pp iii+867–972+plate 5 50 cents Bulletin 1046–L Radioactivity and Uranium Content, Sharon Springs Member of the Pierre Shale, Kansas and Colorado By E R Landis Pp iii+299–319+plates 35–38 70 cents Bulletin 1058–C Geology of Geikie Inlet Area, Glacier Bay, Alaska By James F Seitz Pp iv+61–120+plate 6 n p Bulletin 1060–B Geology and Construction-Material Resources of Marion County, Kansas By F E Byrne, C P Walters, J L Hill and L Riseman Pp iv+63–95+plates 3 and 4 n p Bulletin 1086–D Geophysical Abstracts No 175—October–December 1958 By Dorothy B Vitaliano, S T Vesselowsky and others Pp iii+327–465 35 cents Water-Supply Paper 1445 Surface Water Supply of the United States 1956 Part 11 Pacific Slope Basins in California Prepared under the direction of J V B Wells Pp xii+601 2 dollars Water-Supply Paper 1473 Study and Interpretation of the Chemical Characteristics of Natural Water By John D Hem Pp ix+269+2 plates n p Water-Supply Paper 1506 Surface Water Supply of the United States 1957 Part 3–B Cumberland and Tennessee River Basins Prepared under the direction of J V B Wells Pp vii+248 1 dollar Professional Paper 260–V Larger Foraminifera from Eniwetok Atoll Drill Holes By W Storrs Cole Pp iii+743–784+plates 230–249 n p Professional Paper 314–E Classification, Delineation and Measurement of Non-parallel Folds By John B Mertie, Jr Pp iii+91–124 30 cents Professional Paper 314–F Sedimentary Studies in the Middle River Drainage Basin of the Shenandoah Valley of Virginia By Dorothy Carroll Pp iii+125–154+plates 14 and 15 70 cents (Washington, D C Government Printing Office, 1959) [225

A Special Report of Gravity, Electricity, Atomic Technique and Survival Pp 8 (Toledo, Ohio Alpheus J Roberts, 5722 Tele Road, 1959) [225

Canada Department of Agriculture Annual Report of the Forest Insect and Disease Survey, Forest Biology Division, Science Service, 1958 Pp 114 (Ottawa Queen's Printer, 1959) [225

Canada Department of Mines and Technical Surveys Geological Survey of Canada Memoir 290 Bay of Islands Igneous Complex, Western Newfoundland By Charles H Smith Pp vii+132 (10 plates) 1 25 dollars Memoir 292 Dewar Creek Map Area, with special Emphasis on the White Creek Batholith, British Columbia By J E Reesor Pp vii+78 (7 plates) 75 cents (Ottawa Queen's Printer, 1958) [225

Smithsonian Miscellaneous Collections Vol 139, No 1 The Oldest Known Reptile, *Eosauravus copei* Williston By Frank E Peabody Pp iii+14+1 plate (Publication No 4377) (Washington, D C Smithsonian Institution, 1959) [225

Bulletin of the Florida State Museum, Biological Sciences Vol 4, No 1 A Tabular Summary of the Biology of North American Mayfly Nymphs (Ephemeroptera) By Lewis Berner Pp 58 Vol 4, No 2 Growth and Development of the Eastern Harvest Mouse, *Reithrodontomys humulis* By James N Layne Pp 59–82 Vol 4, No 3 A Checklist of the Chironomidae (Insecta) of Florida (Diptera Chironomidae) By Elisabeth C Beck and William M Beck, Jr Pp 83–96 (Gainesville, Fla Florida State Museum, 1959) [225

National Academy of Sciences, India Symposium on the Chemistry of Co ordination Compounds, Agra, February 7 and 8, 1959 Symposium Handbook Pp ii+121 Recent Advances in the Chemistry of Co-ordination Complexes (Presidential Address) By Prof P Ray Pp 24 India's Contribution to Co-ordination Chemistry By Arun K Dey Pp 68 Recent Researches on Co-ordination Compounds in Japan By Kazuo Yamasaki Pp 7 (Allahabad National Academy of Sciences, 1959) [225

ICSU Review, Vol 1, No 1, (January, 1959) General Editor Sir Harold Spencer Jones Published quarterly for the International Council of Scientific Unions Pp i+56 Subscription price 16 florins, 30*s* , or 4 50 dollars, per volume of approx 200 pages (4 issues) Single copies 4 25 florins, 8*s* , or 1 20 dollars (Amsterdam Elsevier Publishing Co , 1959) [285

World Meteorological Organization Technical Note No 27 Use of Ground-Based Radar in Meteorology (Excluding Upper-Wind Measurements) Report prepared by a Working Group of the Commission for Instruments and Methods of Observation Pp xvi+8 (WMO–No 84 TP 35) (Geneva Secretariat of the World Meteorological Organization, 1959) 9 Swiss francs [28

Publications de l'Institut National l'Étude Agronomique du Cong Belge Carte des Sols et de la Vegetation du Congo Belge et du Ruanda Urundi 13 Region du Lac Albert A Sols C Utilisation de Sols Notice Explicative de la Carte des Sols Par A Van Wambeke Pp 50 (Bruxelles Institut National pour l'Étude Agronomique d Congo Belge, 1959) [28

Institut Royal Meteorologique de Belgique Observations Ionospheriques—Station de Dourbes Novembre 1957 Pp 26 Decembr 1957 Pp 26 Janvier 1958 Pp 26 Février 1958 Pp 26 (Uccle Bruxelles Institut Royal Meteorologique de Belgique, 1959) [28

United States Department of the Interior Fish and Wildlif Service Fishery Bulletin 147 Some Uses of Statistical Analysis i Classifying Races of American Shad (*Alosa sapidissima*) By Donal R Hill Pp iv+269–286 (Washington, D C Government Printin Office, 1959) 20 cents [46

Scientific Research in Mellon Institute 1958–1959 Annual Report o the Chairman, Matthew B Ridgway, to the Board of Trustees of th Institution, for the Fiscal Year ended February 28, 1959 Pp x+38 (Pittsburgh Mellon Institute, 1959) [4

International Atomic Energy Agency Bulletin, Vol 1, No 1 (April 1959) Pp 24 (Vienna International Atomic Energy Agency 1959) [4

Retinal Degeneration Combined with Obesity, Diametes Mellitu and Neurogenous Deafness A Specific Syndrome (not hithert described) Distinct from the Laurence–Moon–Bardet–Biedl Syndrome A Clinical, Endocrinological and Genetic Examination based on Large Pedigree By C H Alstrom, B Hallgren, L B Nilsson an H Åsander (*Acta Psychiatrica et Neurologica Scandinavica*, Supplementum 129, Volumen 34, 1959) Pp 35 (Copenhagen Ejna Munksgaard, 1959) [4

United States Department of Commerce Weather Bureau Technical Paper No 15 Maximum Station Precipitation for 1, 2, 3, 6 12, and 24 hours Part 23 California (including supplement fo December 1955–January 1956) Pp ii+341 (Washington, D C Government Printing Office, 1959) 1 50 dollars [4

Ministério do Ultramar Junta de Exportacao do Algodao Centr de Investigacao Cientifica Algodoeira Memórais e Trabalhos, No 26 A Agricultura do Arquipélago de Cabo Verde Cartas Agricolas—Problemas Agrários Por António José da Silva e Luis August Grandvaux Barbosa (Separata das Memorais da Junta de Investigacoes do Ultramar, 2, 1958) Pp 178+77 plates+10 maps (Lisboa Ministério do Ultramar Junta de Exportacao do Algodao, 1958) [46

Bulletin of the American Museum of Natural History Vol 117, Article 3 The Geology and Paleontology of the Elk Mountain and Tabernacle Butte Area, Wyoming By Paul O McGrew, with the collaboration of Jack E Berman, Max K Hecht, John M Hummel and Albert E Wood Pp 117–176+plates 50–57 (New York American Museum of Natural History, 1959) 1 50 dollars [46

Smithsonian Contributions to Astrophysics Vol 3, No 5 Doppler Widths of Solar Absorption Lines By Barbara Bell and Alan Meltzer Pp ii+39–46 (Washington, D C Government Printing Office, 1959) 20 cents [46

l'Enseignement des Sciences, Tome 1, Numéro 1 (Mai-Juin, 1959) Pp 48 Abonnement 1 an, 5 numéros—France et Communauté 1,200 francs , Autres pays 1,500 francs (Paris Hermann, 1959) [46

New Zealand Forest Service Annual Report of the Forest Research Institute for the year ending 31 March, 1958 Pp 100 (Wellington Government Printer, 1958) [46

National Academy of Sciences—National Research Council Nuclear Science Series—Report No 27 Source Material for Radiochemistry Pp iii+23 (Washington, D C National Academy of Sciences—National Research Council, 1959) [46

Metropolitan Life Insurance Company Statistical Bulletin, Vol 40 (April, 1959) Hospitals Promote the Nation's Health Family Responsibilities Increasing Half Billion Dollars paid in Death Claims in 1958 Falls a Major Cause of Death Pp 12 (New York Metropolitan Life Insurance Company, 1959) [46

Durban Museum Novitates Vol 5, Part 14 A Tentative Grouping of the Species of the Genus *Crocidura* Wagler, 1832 (Insectivora Soricidæ) Occurring in Africa By G H Swynnerton Pp 185–189 1*s* 6*d* net Vol 5, No 15 A New Subspecies of Lesser Long-Winged Bat *Miniopterus* Minor Peters, 1867, from the Comoro Islands By David L Harrison Pp 191–196 (Durban Durban Museum, 1959) [46

Commonwealth of Australia Tenth Annual Report of the Commonwealth Scientific and Industrial Research Organization for the year 1957–58 Pp 174 (Canberra Government Printer, 1958) 14*s* [64

World Health Organization Technical Report Series No 169 Joint WHO/FAO Expert Committee on Zoonoses—Second Report Pp 83 2 Swiss francs , 3*s* 6*d* , 0 60 dollars World Directory of Venereal-Disease Treatment Centres at Ports Pp 162 5 Swiss francs , 8*s* 6*d* , 1 75 dollars (Geneva World Health Organization , London H M Stationery Office, 1959) [46

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THE DISCIPLINE OF THE SCIENTIFIC METHOD

THE address, "The Message of Science", which Prof. P. Weiss delivered at the Universal and International Exposition at Brussels on June 25, 1958, and which has now been issued as an Occasional Paper of the Rockefeller Institute, develops three main points. Man's hope lies in the advance of civilization, of which science is a part, and to understand the role of science requires insight into its nature, power and limitations. First, Prof. Weiss argues, man will continue to reap rich fruit from scientific progress. Secondly, understanding the process of science gives man a firmer grounding in reality against his floundering and fumbling in abstractions; and thirdly, the task of science is to serve man by mastering Nature and not to become man's master. In serving man, science, Prof. Weiss urges, must close ranks with other servants of humanity—the creative arts, philosophy, religion—all striving for a new integrated humanism.

In this view, science, which has helped to dethrone man from his self-appropriated station as the centre of the universe, can help him now to grow into his rightful stature. Prof. Weiss's address is thus essentially a contribution to the discussion on the place of the universities in the scientific revolution which Sir Eric Ashby opened in "Technology and the Academics" and which Sir Charles Snow has developed further in his Rede Lecture, "The Two Cultures and the Scientific Revolution"[*]. Prof. Weiss does not disparage the material benefits which science can provide, but he lays his stress on the contribution which science can offer to man's intellectual and moral advance. It would be a distortion to suggest that he is advocating science for its own sake; but, like Sir Edward Appleton in his presidential address in 1953 to the British Association, he maintains that science itself is one of the great human values.

The power of science, Dr. Weiss points out, comes from the strict mental discipline and critical detachment that it imparts to those who live and practise by its code; and if living by this code can help men to lead more satisfying lives, so as more fully to enjoy and share promised release from want and drudgery; if science will not just extend man's span of life but also give the content of that span more purpose; if science can convince man that many of the evils and errors and convulsions of the present age arise from his ignorance and neglect of the very code of science; then science will have given him another noble gift, namely, a basis for responsible and judicious self-direction as a design for living. This presupposes that man is free to choose his course for better or for worse, and in this choice, the scientific approach can help him to avoid predictably disastrous turns and missteps. Science is not to blame for man's misdirecting scientific knowledge to evil ends.

If the scientific spirit can teach man reason, the message of science must, however, first be accepted by man, and it is Sir Charles Snow's contention that one of the two cultures he predicates as existing does not and will not accept that message. First, however, the characteristics which Dr. Weiss describes as marking the scientific spirit as superior to the mere application of logic, the Golden Rule, or just plain common sense should be noted. It is the categorical demand for validation and verification of each premise, each contention and each conclusion by the most rigorous and critical tests of evidence. Every rule and law have to be tested and enforced, and nowhere else is the penalty for error or infringement so prompt and telling.

This discipline of the scientific method, broadly applied, could go far toward clearing the underbrush of superstition and prejudice that hampers civilization in its march, but it has its limitations. Since, according to the code of science, no positive assertions are final and all propositions approximations, and indeed provisional, science is seen to advance more by denying what is wrong than by asserting what is right—by reducing, and eventually eradicating, errors rather than by heading straight toward some preconceived final truth. From any point along the frontier of knowledge which mankind faces, the imagination and curiosity of individuals may start tracks that radiate in all directions into the unknown. Through trial and error the right path is gradually singled out from the multitude of blind alleys by the fact that it has met, instead of missing, other new or familiar lines starting from other points, merging with them in mutual reinforcement. Success lies in the confluence of thoughts from many diverse directions, and this gives science its coherence and consistency, with a stable inter-convertible currency of terms and units, modes of operation and standards of proof or disproof, all gained by gradually removing the inconsistencies and incongruities within the system, by the systematic reduction of margins for error.

Dr. Weiss points out that this is the method of organic evolution, but on the infinitely faster scale of thought processes, which require much less time to establish their soundness; and from this comes man's unprecedented chance for rapid progress—from the incessant weeding out of error. Moreover, for science as a whole, truth is that strip of possibilities left over after all demonstrable untruths have been eliminated; there will remain a fairly broad band of uncertainty, including the indeterminate, the unknown, the indeterminable and the unknowable The limits of science are frankly acknowledged, and Dr Weiss has no place for either the shallow optimism that Sir Charles Snow marked as contributing to the divergence of the two cultures he describes, or for the uncritical claim that science is a cure for all the ills of mankind and that it can prescribe ultimate goals to guide man's conduct On the contrary, the humility and courage required to live with partial answers and the disturbance of complacency should assist science—and the scientist —to live with the other claimants to a share in human destiny. The scientific spirit, by stimulating man afresh to search and strive again rather than to conform, to face problems and not to accept past solutions, and to exercise ingenuity instead of abdicating to authority, could rekindle flames which mechanization threatens to extinguish

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[*] The Two Cultures and the Scientific Revolution. By Sir Charles Snow. (The Rede Lecture, 1959.) Pp. iv+52. (Cambridge: At the University Press, 1959.) 3s. 6d. net.

Dr Weiss's view of the relations of science with the creative arts, with philosophy, with at least the kernel of religions (not of creeds) and with the lessons taught by history, all of which are companions with science in shaping the fate of mankind, presupposes, however, a bridge rather than the gulf which leads Sir Charles Snow to speak of the two cultures—it invokes comprehension rather than incomprehension on both sides If the attitude which he depicts should prevent the scientist from contributing to misunderstanding or stirring up resentment, there must none the less be understanding and not prejudice on the other side It will not suffice for science to be objective, to recognize soberly its own limits, and to claim no greater share of man's allegiance than it can ask on scientific grounds It can scarcely act as educator unless there is sympathy and receptiveness on the other side That must precede the abatement of suspicion and resentment, the removal of barriers due to prejudice and the disappearance of any fears of aggressive expansionism of science

This exposition of the message of science ends with an appeal that men of science should close the ranks with those in other walks of life against the dehumanization of our culture, and that they should look and work for a broad humanism in which science is accepted, not grudgingly but with understanding, by all men in all walks of life, not for its fruits alone but for the ideal of rational thought which it can carry to its highest culmination At the same time, men of science must ever be on their guard against the danger of specialist isolation to the neglect of other human values, and finally Dr. Weiss pleads that science should re-acclaim diversity as the source of progress, including the diversity of human minds in their responsible expression Simultaneously, he pleads that those humanists who are not scientists should not regard themselves as the prime custodians of civilization, shunning science as if it were inhuman.

The conception of the message of science and the place of the scientist in our civilization which Dr Weiss expounds in this address is dignified and noble as well as restrained, it could well elicit the response he seeks from the non-scientists if it can reach them But while Dr Weiss recognizes as clearly as Sir Charles Snow the gap between the two cultures and the imperative need for co-operation between scientist and non-scientist, he does not indicate how the gap is to be bridged It is true that, if his counsel is followed, scientists could do a good deal to remove the prejudices and suspicions which have enlarged the gap—or at least to remove the substance of those prejudices and suspicions, but something more is required to restore unity to the intellectual life of Western society, or even to provide a meeting place for the two cultures The lack of comprehension of science and technology on the part of the non-scientist which leads Sir Charles Snow to describe the literary intellectuals as natural Luddites must be removed also, and this as he sees clearly is a problem of education Until intellectuals and the nation generally come to understand the scientific revolution and its implications, Britain cannot hope to cope with the problems offered and either avert the dangers or exploit their possibilities

Sir Charles Snow faces this question in the last part of his lecture He believes that we need as many outstanding scientists as the country can produce They present no problem, but their number is limited, and they need a much larger number of professional scientists for the supporting research and high-class design and development, here the problem is not so much that of quality as numbers These in turn require a large number of supporting technologists and technicians for the secondary technical jobs, some of whom will take major responsibility, particularly in the human jobs Here our problem is both the numbers required, which will throw an immense strain on the universities, university colleges, colleges of technology and technical colleges of Britain, and the distribution of ability in order that proper and efficient use may be made of their services Lastly, there must be not merely politicians and administrators, but also an entire community knowing enough science to have a sense of what the scientists are doing

Sir Charles offers no prescription as to how all this is to be achieved He simply presents the challenge to the educational system of the country, with the reminder that our real assets in the world to-day are our wits—our capacity for co-operation and our inventive and creative ability The survival of Britain as a world power requires that we should fully understand the scientific revolution, educate ourselves to the limit and give the lead to the world We cannot do this without breaking the existing pattern of education; but unless we do so and educate ourselves adequately, we must experience in our own life-time a steep decline in our standards of living To close the gap between the two cultures is a necessity in the most abstract intellectual sense, as well as in the most practical, in order that we may be able to achieve even the political techniques which will enable us to bring our human capabilities into action Once again we are summoned to look at education in the broadest sense, and Dr Weiss's message is an invaluable contribution to such a task

LATIN IN UNIVERSITY ENTRANCE REQUIREMENTS

THE controversy about compulsory Latin for entrance to Oxford and Cambridge flares up sporadically, like the plague, but it does look as though the recent outbreak may be the last. True, Oxford has reversed its decision to make German and Russian alternatives to Latin, but when the committee at present looking into the qualifications for university entrance reports, it seems likely that some means will be recommended whereby Latin can be avoided.

It is difficult to see what benefit the average boy (or girl) who wants to specialize in science can derive from Latin at Ordinary level in the General Certificate of Education. He will not be able to read the simplest texts with any ease, even if he wanted to, and the feeling among many scientists that Latin is a waste of time makes it very unlikely that he will. His attitude to Latin, which is often crammed in a few months and as quickly forgotten, is one of resigned hostility.

"Without Latin the specialists will become even more specialized" is a favourite argument of the anti-abolitionists, yet very few people wish to abolish it unconditionally. At Oxford the suggestion was that Russian and German should be alternatives, and a scientist with French and German is no more a specialist than one with French and Latin. Besides, there is far more chance that a modern language will be kept up, since even the least materialistically minded can see its usefulness. More and more people go abroad every year, especially school children and university students, and later on the professional scientist will want to read papers in foreign languages. Few are published in Latin.

Three main arguments are advanced by those who wish to see Latin retained besides the one mentioned above.

First, they say that it is the key to the understanding of Western culture. Quite apart from the fact that Latin at Ordinary level is not even a key to the understanding of Latin, in order to 'understand' Western culture one has to know a good deal about it, and, as is so frequently pointed out, most scientists do not—though many are more knowledgeable than is often allowed. Latin is, no doubt, an immense asset to the scholar with a wide knowledge of the literature, philosophy, art and history of Europe and America, but to the scientist it is rather like studying the quantum theory without knowing what radiation and algebra are; or, to take a non-scientific simile, to study the sources of Shakespeare's plays without having read "Hamlet". With an educational system which imposes specialization at the age of fifteen we cannot afford the time for intellectual luxuries. It is the stuff of Western culture that should be studied, not Latin grammar.

Secondly, Latin is said to be a unique training for the mind. This argument is difficult to refute, since it is so vague and is so seldom elaborated. It is significant that it is usually advanced by people whose mental training was largely based on Latin. Furthermore, mathematicians can make a similar claim for mathematics with equal justice. Part of the uniqueness of Latin is said to lie in its being a highly inflected, and so a very precise, language; but so are German and Russian.

Thirdly, Latin is said to improve one's English. Maybe it does, but it is an extraordinarily roundabout way of doing so, and one for which the scientist simply does not have the time.

In fact, Latin tends to defeat the very objects it is meant to attain. It becomes associated with other non-scientific subjects and produces an anti-cultural reflex—Latin is a waste of time, therefore French, history and English are a waste of time. It also takes up valuable hours in school which might be devoted to arts subjects likely to interest the potential scientist. It is not suggested that the time spent on Latin should be given over to more science. A debate held recently in the University of London on the motion "That the Education of our Future Rulers should be primarily in the Sciences rather than the Humanities", where scarcely a speaker from an audience containing many scientists supported the motion, shows how much basic agreement there is that education ought not to become too specialized. In view of this, it is a pity that such an issue should have been made out of the relatively unimportant Latin question.

It is high time that some effort was made towards improving the general, as opposed to the specialized, standards for university entrance. If the Latin dispute does nothing else, it focuses attention on this need. Scientists entering for State scholarships already have to take a general paper in English, but it is a special paper for scientists, and so in a sense it condones the existence of Sir Charles Snow's two cultures, instead of tending to re-unite them. If only the universities would demand from everyone three subjects at Advanced level, one a science and one an arts subject, there would be no need to quibble about trivialities like Ordinary level Latin. Quite apart from the wider knowledge this would bring, scientists and arts men would be working together right up to the time they left school, and this is surely essential if they are not to separate into two groups. It has been suggested that as a consequence there would be a slight lowering of standards in the entrance scholarships, and that the colleges would not accept this. If so, it would be a great pity, but it would be a very small price to pay. Besides, it is illogical to complain about specialization and to object to measures which combat it.

Anyone who wants to see compulsory Latin retained for scientists should sit back and ask himself two questions. What am I trying to achieve? What is the best way of going about it? It is very peculiar reasoning that produces Latin at Ordinary level as an essential part of the final answer. The worthy cause of a wider education is being discredited.

THE LIFE OF FREDERICK SODDY

Pioneer Research on the Atom

The Life Story of Frederick Soddy By Muriel Howorth Pp 352+16 plates. (London New World Publications, 1958) 75*s*

THIS is an uneven and uneasy book The scientist who reads it is likely to be exasperated by its not infrequent confusions and repetitions—and the general reader will almost certainly find its detailed chronology difficult if not impossible to disentangle, although the framework of the story is simple enough It is the life-story of Frederick Soddy, pieced together from his casual remarks, from reluctant replies to leading questions, from more sustained and possibly more spontaneous reminiscence, and from the residue of his papers, by his literary executrix and friend of his later years It is a work of obvious devotion, forcefully and at times movingly written, but it achieves no real synthesis

Readers of this journal will remember Paneth's tribute to Soddy (*Nature*, 180, 1085 , 1957) within the compass of a short article, that was generous, just and discerning, written by an expert in his own field who had known him when he was still active in it Paneth wrote "The duty to clarify his picture is specially incumbent on us, as it is the tragedy of his life that members of the younger generation may know him only as the person who adopted the term 'isotope', and, perhaps, as the author of provocative statements in economics and other fields far remote from science The number of those who knew Soddy in his creative period is dwindling He was gifted in many, perhaps too many, ways He was such a good writer of English prose that it was all too easy for him to give his polemical essays the sting he wished"

Frederick Soddy died on September 22, 1956, in his eightieth year His last contribution to the literature of radioactivity was a letter to *Nature* published on September 3, 1932 His present biographer met him first in January 1953 She had then recently read "The Interpretation of Radium" (1909) and had been so impressed by its philosophy that she had sought out its author At their first meeting she suggested to Soddy that they should "together write the record of his scientific investigations" Within a few days she had his agreement Within two months the preface, at least, to "Atomic Transmutation the Greatest Discovery ever Made" had been written This was to be Volume 1 of the Memoirs Volume 2 was unfinished at Soddy's death Then Major and Mrs Howorth came into possession, through Soddy's will, of "all his original papers, letters, and records" In that way the book now under review had its beginning, its conception replacing that of the half-finished Memoirs "Having these [original papers] as my guide", Mrs Howorth confides in her new preface, "I can now write, with less presumption and more confidence, the story of this remarkable man who was destined to play so great a part in the discovery of one of Nature's phenomena, unique in its potentialities and formidable in its power"

It appears to me necessary to give this brief history of Mrs Howorth's book—essentially in her own words—but having done so I am left with scant space to comment on it further In any event I should require many pages to deal with it in detail I can only indicate its shortcomings and its virtues by further quotation "Later, when the speaker at one of the Royal Society Popular Lectures in Canada fell sick, Professor Cox telephoned Rutherford to take his place and this led to his being accorded a Fellowship of the Royal Society of Canada and eventually to the full London Fellowship in 1903" (p 78) , "Superb chemist that she was Marie Curie had foreseen these events, but it was left to Frederick Soddy to establish each one of them by experiment—natural transmutation, 1901 , disintegration theory, 1902 , displacement law, 1911" (p 93) , "By 1905 it was still not confirmed that the alpha particle was a helium nucleus" (p 114) , "In 1932, Harkins's 'neutron' had been experimentally established by Chadwick Later Chadwick went to study in Germany under Nernst and Rubens " (p 129) , " when Cockcroft and Walton in the Cavendish Laboratory succeeded in 'splitting the atom' Cockcroft alone received the award [of a Nobel prize]" (p 188) , 'What exactly is a beautiful equation ?' I asked [Professor Dirac] 'Is Einstein's little mass-energy equation beautiful ?' 'No, that is not beautiful,' he replied, 'but some equations are very beautiful indeed' (p 257) , "One can say that on Soddy's perception the whole of nuclear science has been built" (p 267) , "The loneliness which such inattention from the scientific world creates is sometimes not easy to bear without resentment It may be also, in the case of Soddy, that the loneliness of his early days returned One could imagine that his mother died three times, once in his infancy, once with the death of his wife, and once on his retirement from academic life" (p 277)

I do not think that the historian of the science of this century will pass over the work and the worth of Frederick Soddy, as he himself found it for a season passed over—or imagined that he found it passed over—in his later years He is assured of the esteem of posterity, without special pleading Mrs Howorth's book contains much that will be of interest to the historian, but her special pleading is likely to pass him by NORMAN FEATHER

GUIDE TO MODERN PHYSICS

Handbook of Physics

Edited by Dr E U Condon and Dr Hugh Odishaw (McGraw-Hill Handbooks) Pp xxvi+1462 (London McGraw-Hill Publishing Company, Ltd , 1958) 194*s*

THIS is a magnificent book It contains about 1,500 pages and weighs nearly 3 kgm , dimensions which are achieved by solid packing of authoritative information, with little padding or wordy introductions We have considered it from the points of view both of the senior who has had ample opportunity of forgetting his physics, and of the student who is in the process of acquiring it For both it seems to be an excellent work of reference

It is divided into nine parts mathematics, mechanics of rigid bodies, mechanics of deformable bodies, electricity and magnetism, heat and thermodynamics, optics, atomic physics, solid state, and nuclear physics Each part is divided into about ten chapters, each written by a specialist , there are nearly ninety contributors, practically all from the United States The list of chapters would be too long to enumerate here, but some idea of the contents can be given by saying that the topics are those in which there is considerable interest at the present time. The book gives a general impression of the rapid development of physics in many different directions.

This development has introduced the usual difficulties in keeping the subject-matter up-to-date, and in the preface the editors express some concern about their success. They need not have worried; most physicists would be only too delighted to keep within hailing distance of the amount of physics in this book.

In fact the main criticism of the book is that it does not seem clear about its own purpose. In the preface the editors imply—but do not clearly state—that they regard the contents as "What every physicist ought to know". Surely the claim is outrageous? There can be very few people who have the mental capacity for absorbing all this material; and it is questionable whether such people would best serve physics by spending the time needed for its absorption.

In our opinion, the main purpose of the book is to serve as a work of reference for the expert who has occasion to wander into a field related to his own but unfamiliar to him. He will find the general principles authoritatively and clearly set out, and will be able to see the types of mathematical approaches that are used. He will not usually find experimental details—except for occasional chapters on such subjects as experimental stress analysis, and vacuum technique—since the book is essentially theoretical.

The mathematical part of the book is perhaps the least satisfactory. It contains some elementary material such as logarithms, which seems out of place, and some, such as the theory of probability, which is likely to be of more use to biologists than to physicists; on the other hand, the theory of errors is not treated. Nevertheless, the main content is extremely good and well set out.

The book is beautifully printed and produced, and we have noted only very few misprints and mistakes. Unfortunately, the very high price—which is quite reasonable for the amount of material contained—will probably rule it out for most individual physicists. It should nevertheless be in every library and, more important, every physicist should know of its existence.

H. Lipson
S. G. Lipson

REACTION KINETICS

Some Problems in Chemical Kinetics and Reactivity, Vol. I

By N. N. Semenov. Translated by Michael Boudart. Pp. xii+239. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1958.) 36s. net.

THIS is the second English translation of the first volume of Prof. Semenov's book on "Some Problems in Chemical Kinetics and Reactivity" to appear in the past few months. Reading it, one is immediately struck by the strength of the author's grasp of the fundamental issues of reaction kinetics, and by his ability to marshal the evidence in a subject where the experimental results are often confused, and their interpretations conflicting.

The volume under review has no pretensions to being a text-book, and is in fact an extended version of an introduction to a symposium held in Moscow; it thereby retains a certain freshness and is notable for the provocative and stimulating points of view which it takes. It begins with a classification and account of reactions of monoradicals (no nonsense about 'what is a radical ?'), a chapter which is to be commended for its discussions on bond energies and the relation of energy of activation to heat of reaction, and for the cautious but telling way in which the relation of structure to reactivity is dealt with. The next section is on competition between monoradical reactions, and here a clear account of the role of peroxides in oxidation of hydrocarbons is to be found; a great deal of modern Russian work of value, much of it unfamiliar to this reviewer, is dealt with here. The mechanism of chain decompositions of hydrocarbons is discussed.

In dealing with diradicals a distinction between the physical concept (triplet state, paramagnetism) and the chemical concept (absence of activation barriers, tending to dimerize, weakness of the second bond) is exemplified at the outset, although there is a general coincidence. The chemical aspects, as would be expected, are stressed.

After this survey, the second (and final) part of the volume deals with chain initiation and termination. This is divided into chapters on dissociation of molecules and recombination of radicals (essentially by homogeneous processes), initiation by ions of variable balance, and the influence of the walls of the reaction vessel. All these are excellent, the last being particularly recommended. It leads to some interesting speculations on the processes of heterogeneous catalysis.

The standard of production of the book is not high, the typescript being rather unsatisfactory, with an irritating and unnecessary symbol for the chlorine atom. The translation is quite good, although marred by a few words like 'organicist', and expressions such as "the 'ion-impact' method imagined by V. L. Tal'roze . . .". For a physical chemist, however, this book of Semenov's should be compulsory reading.

T. M. Sugden

CHEMICAL OCEANOGRAPHY

Apparatus and Methods of Oceanography

By Dr. H. Barnes. Part 1: Chemical. Pp. 341. (London: George Allen and Unwin, Ltd., 1959.) 40s. net.

THE special methods of analysis used in chemical oceanography and marine biology are to be found in a great many different publications, some of which have limited circulations. There is a need for a collection of working methods, preferably with some guidance for the inexperienced. The need is very competently met by this book. Although suitable for the experienced analyst, it is also explicitly intended to help biologists with less chemical knowledge, and to be useful to those with small libraries. The author has therefore devoted the first quarter of the book to three chapters on colour comparators and photometric analysis, to errors and precision, and to the calculation of results. It is difficult to judge the value of this part of the book. It is well done; indeed, it is admirably clear, but much of it seems unnecessarily elementary, and some of the instruments described are surely obsolete.

The rest of the book is very useful indeed. Separate chapters (several for nitrogen and phosphorus) give methods for determination of chlorinity, *p*H, nitrogen, phosphorus, silicon, carbon, oxygen, alkalinity (an account of the carbon dioxide system is interpolated), conservative elements by micro methods, trace metals and plankton pigments. Others describe filtration methods, and sediment analysis. In each chapter, introductory notes explain the application and chemistry of the methods, which are then given tersely in a form easy to follow at the bench. Remarks on matters of technique, interference, and accuracy come last. The methods are well chosen and it is evident that Dr. Barnes is drawing on considerable experience. It is a little surprising that he does not mention the determination of *p*H with indicators, as it is easy to get quite good results with very simple gear. He should be well able to explain and set out the corrections needed for this method, which is still in use.

There are more than 420 references, some 60 of which are in an appendix bringing them up to July 1958. These are invaluable, although there are few from Russian sources. The 45 tables are mostly relevant; but it is not easy to see the need for reciprocals of atomic weights, nor for a complete list of the symbols recommended by the Chemical Society. The index is thorough. The binding and paper seem rather too absorbent for a book which is certain to be used a great deal on the laboratory bench. F. A. J. ARMSTRONG

ATLANTIC HYDROMEDUSAE

The Carlsberg Foundation's Oceanographical Expedition round the World 1928–30 and Previous "Dana" Expeditions

"Dana" Report No. 46: The Hydromedusae of the Atlantic Ocean and Adjacent Waters. By P. L. Kramp. Pp. 283+2 plates. (Copenhagen: Andr. Fred. Høst and Son, 1959.) 60 Danish kr.

THIS work, by one of the world's most knowledgeable experts on the subject, is a valuable addition to the excellent series of *Dana* Reports. It will partly replace and partly help to guide us to the multitudinous works on medusae in so many scattered journals, although it has not a complete literature list.

One might wonder how far this new volume overlaps Russell's monograph on the "Medusae of the British Isles" published in 1953 and if it is necessary or desirable for both to be at hand. That there is considerable overlap is inevitable and as it should be, but the two serve distinct purposes. Russell is confined to British waters—but not as defined by the Convention!—and it has much more detailed descriptions with details of the hydroids and their development where these are known. Kramp covers a much wider field. An example which illustrates this difference is given by the genus *Phialidium*. Russell describes two species but Kramp twelve and four doubtful ones. Kramp's description of *P. hemisphaericum* is contained in ten lines, and Russell's in ten pages.

This new report is in three sections. The first occupies 74 pages and is a systematic account of the species taken on the *Dana* cruise, 1928–30, and in collections made at the request of the *Dana* Committee. Not only are very full taxonomic descriptions given, often clearing up doubtful nomenclature, but also brief but useful summaries of distribution, both geographically and in depth. It contains descriptions of three new species and one new subspecies.

The second section, of more than a hundred pages, is a survey of all the hydromedusae which have up to now been found in the Atlantic and adjacent waters, a term interpreted to include the Caribbean, Davis Strait and Baffin Bay, the Mediterranean, Black Sea and the waters north of European U.S.S.R.: truly a wonderful coverage. This section will be a boon to those struggling with the systematics of medusae as it has a diagnosis of every family, genus and species, and with keys to all species at present considered valid. It makes extensive use of Russell's book and his Plankton Sheets for those species that are given therein, but its wider field will make it a most valuable aid towards the determination of medusae by workers everywhere. The descriptions are concise and their arrangement helps to make them simple to follow. The keys, too, are clear, and if only the medusae themselves were always as clear their determination would be much easier. It is scarcely the author's fault that medusae are so often damaged that in practice the answer to some of the questions may be just a question mark. Because of the changes during development the section is confined to the adult forms. This is a pity because so often the young stages found in the plankton can be puzzling. I was disappointed to see that Kramp had not done more to link the medusae with their hydroids as there is now a great deal of information on this, but he probably considered it to be outside the particular relevance of the book. Doubtful species are mentioned in case future research should point to their validity. In this section, too, their distribution is concisely mentioned.

The third section is for the ecologist and it describes the composition of the fauna of the hydromedusae within each of the zoogeographical regions of the area—the Black Sea excluded—and based on the distribution of the water masses. The number of regions is generous in its coverage, with details separately given for four ecological groups—neritic, slope, oceanic epipelagic and bathypelagic—each being regionally subdivided. The neritic group is given extensive subdivision, first into eight major regions, for example, Arctic, East Atlantic Boreal, etc., and then into provinces, for example, Atlantic coasts of the British Isles, Channel, North Sea, Baltic, Norway north of Bergen, Iceland. Russell, in 1935, laid stress on the value of certain medusae as 'indicator species', and the detail given in this section of Kramp's book will be invaluable in this respect. It is only to be expected that further research will widen our knowledge of the distribution of many of the medusae, and although it is obvious that Kramp realizes this (for example, at the bottom of p. 266), I found some of his statements too dogmatic, and once in error. On page 210 he says that *Ptychogena lactea* is "entirely lacking in the East-Atlantic boreal region". The *Scotia* took this species in the Faroe Channel in June 1958, and indeed Kramp himself confirmed the identification.

Like other *Dana* Reports, the proof-reading and production have been excellent. Those interested in the systematics of medusae or in the ecology of the water masses will certainly want to have this volume, and I have no doubt that their copy will before long be well thumbed. J. H. FRASER

An Anthropologist at Work

Writings of Ruth Benedict By Margaret Mead Pp xxii+583+8 plates (London Martin Secker and Warburg, Ltd , 1959) 42*s*

RUTH BENEDICT and Margaret Mead are two of the best-known names in American anthropology, and certainly the best known to the general public, because their writings have a popular appeal and have appeared in cheap editions This is a book by the second about the first, or rather it is a book about Ruth Benedict and her circle, among whom Margaret Mead was a prominent figure, as she is in the book It contains a number of articles—and also poems—by Ruth Benedict interlarded with introductory pages by Margaret Mead Some of the articles have already appeared in print elsewhere, and the unpublished ones contain so little of scientific interest that it scarcely seems worth while committing them to print , and, indeed, it must be said that much of Ruth Benedict's writing fell into the class of higher journalism rather than into that of scientific anthropology It could, however, be said that it is often helpful in evaluating an anthropologist's writings to have some knowledge of him as a person and of his private interests That would be true, but a brief memoir would have served the purpose better than a book of more than 500 pages and so constructed that the subject of the memoir is constantly interrupted by its editor and the editor by its subject Moreover, even an English anthropologist, who might be expected to find an account of his American colleagues of interest, may find, as I have, the company somewhat dull Those who are not anthropologists will, I fear, find it tedious, for what can be more tedious than the doings and views of persons we have scarcely heard of, and persons of no very great importance ? An answer to that question might be, the revelation of their feuds and personal antipathies Some of the gossip may be true and might be spoken, but it ought not to have been published in print so soon—for example, what is said about the late Prof Radcliffe-Brown , for it is not as though relations between other persons mentioned are treated with complete candour It is a pity that the initial sympathy and admiration which many of us have felt towards Ruth Benedict, an able woman who left some important writings behind her, and also towards the centre of the circle, Franz Boas, should in the course of reading this memorial volume be lost

E E EVANS-PRITCHARD

Nuclear Reactors for Power Generation

Edited by E Openshaw Taylor Pp vii+144 (London George Newnes, Ltd , 1958) 21*s* net

THE basis of this book is a short course of lectures given at the Heriot-Watt College, Edinburgh The first and the final chapters provide a reasonable survey of the application of nuclear power The first of these chapters deals with the world energy requirement, and the importance of nuclear power to the United Kingdom, the United States, the U S S R , and the remainder of Europe The final chapter considers the economic application of nuclear power, dealing with the choice of steam cycle, fuel burn-up and the importance of a high load factor In this latter context pumped storage schemes are discussed

The five intermediate chapters provide a short technical survey aimed at providing engineers concerned with the construction and operation of nuclear power plants with a background of information The text is not intended for the designer The chapter on materials is the exception, however, and is more detailed Certainly the designer would find it a useful survey of the likely reactor materials The potential reactor operator would probably advocate more space being allowed for safety and instrumentation, to enable the control systems of the current electricity authorities' nuclear power stations to be described in detail

A considerable training programme for technicians and operators will be necessary as the large nuclear power stations begin to be commissioned from 1960 onwards This book provides a summary of a typical course

R VAUX

Disposal of Radioactive Waste

By K Saddington and W L Templeton Pp x+102 +8 plates (London George Newnes, Ltd , 1958) 17*s* 6*d* net

THE disposal of radioactive waste material is a problem which had to be faced when the production of radioisotopes commenced on a large scale both in Great Britain and elsewhere It will, of course, become of increasing importance as the atomic energy power programme expands and the use of radioactive material increases in industry and the medical fields

The authors have provided a book which should do much to enlighten the general reader and, at the same time, act as a useful work of reference for those working in the field of atomic energy

Although it is claimed that the book is designed to assist sanitary engineers, the main emphasis is on the wastes arising at reactor stations and fuel-processing establishments A more detailed account of the problems arising in industry would have been an advantage

The important biological aspects are described very fully, perhaps too fully, having in mind the class of reader for whom the book is intended Certain of the other chapters could have been expanded to provide more guidance to those outside the U K Atomic Energy Authority

It is quite impossible in a book of this size to give a comprehensive account of all the problems and their solutions Nevertheless, the authors are to be congratulated on a good attempt to provide a general survey of the disposal of radioactive wastes

Selections from Modern Abstract Algebra

By Richard V Andree Pp xii+212 (London Constable and Co , Ltd , 1958) 42*s* net

A BETTER title for this book might be "An Easy Introduction to some Ideas in Modern Abstract Algebra" It is often said that abstract algebra demands little manipulative technique but a considerable degree of mathematical maturity , the object of this book is to enable the novice to acquire that maturity, starting from little more than basic notions about integers and real and complex numbers The early chapters discuss logical ideas and concepts such as equivalence classes and congruence in detail, with plenty of illustrations and exercises chosen over a wide field , explanations are full and generally careful, though the reader may be left in doubt on whether a postulate is or is not the same thing as an axiom (p 11), and the description of a series as "convergent, perhaps finite" (p 24) is unfortunate.

Boolean algebra receives adequate discussion, with examples from logical puzzles and circuit theory

Groups, matrices, determinants fields, rings and ideals are then brought in at a gentle pace, with a wealth of concrete illustration The author does not disdain to exhibit a diagram of the inter-relations of fields, integral domains, commutative rings, rings, which should help the beginner in the rather tiresome task of remembering the connexions and differences of these concepts The Cayley–Hamilton theorem for matrices is proved, and in dealing with groups the reader is led to see the importance of the Jordan–Holder theorem, though the proof is omitted

The author tells us that the lecture courses on which this book is based have been increasingly popular in the University of Oklahoma, and that engineering students have found the work on Boolean algebra and matrices valuable and stimulating One can readily believe this, for the style is easy and informal, most readers will be keen to go further, and for them the carefully selected references to more advanced works will be useful T A A Broadbent

The Terpenes

By the late Sir John Simonsen and Dr W C J Ross Vol 5 The Triterpenes and their Derivatives —Hydroxy Acids, Hydroxy Lactones, Hydroxyaldehydo Acids, Hydroxyketo Acids and the Stereochemistry of the Triterpenes With Addenda to Volume 3 by the late Sir John Simonsen and Dr P de Mayo Pp ix+662 (Cambridge At the University Press, 1957) 84*s* net

VOLUME 5 of this well-known series contains a comprehensive summary, up to about 1954, of work on the subjects named in the title A few references and rather more ideas date to about 1956 An important section is concerned with the classical stereochemistry of the various then known triterpene skeletons, with some consideration of conformational questions As in previous volumes, conformational formulae are inadequately used, but the volume marks a distinct improvement in this respect There is a considerable addendum bringing up to 1956 work on configuration and structure in the sesquiterpene and diterpene series

Inevitably in a rapidly moving field the book is seriously out of date For example, a number of structures quoted have been superseded and many others then unknown have since been determined There is, inevitably, no consideration of important recent methods such as rotational dispersion, but a rather full account of the use of molecular rotation differences However, it can form a starting point for the research worker and provides some useful summaries of more classical aspects of the subject for teaching purposes A J Birch

Carbon Dioxide in Water, in Wine, in Beer and in other Beverages

By F Justin Miller Pp 49 (Oakland, Calif F Justin Miller, 3166 Birdsall Avenue, 1958) 15 00 dollars

THIS memoir comprises three almost independent essays on (*a*) a numerical method of representing the gas pressure relationships in various carbonated beverages, (*b*) the rate at which such beverages become impregnated by the gas, and (*c*) the rate at which the gas is lost from the carbonated liquids under various conditions No radically new conceptions are developed but numerous graphical and tabulated data are included and the discussion covers many vexed questions such as the role of nuclei and agitation in the effervescence of carbonated drinks and the suggestion, not supported in the present thesis, that various forms of bonding of carbon dioxide, for example, to proteins or as "carbonic acid", play a part Some readers may find the presentation rather verbose and obscure and may feel somewhat perplexed by the description of numerous 'experiments' where it is not always easy to appreciate either the objects or the results Furthermore some at least of the ideas will be provocative as, for example, the view that solutions of carbon dioxide in aqueous liquids may be regarded as dispersed systems similar to emulsions It is further suggested that increasing the level of disturbance during carbonation results in a coarser 'emulsion' so that the gas is entrapped in comparatively large aggregates which are unstable and tend to give rise to over-foaming ('wildness' or 'gushing') when the pressure is released While this view may help in describing the phenomenon of gushing, it leaves out of account much that is known from scientific experiment about this behaviour and moreover does not in any material way contribute towards means of controlling or avoiding the defect As this is only one example illustrating the general character of this monograph it will be clear that the latter makes no claim to be comprehensive, but, nevertheless, it contains a good deal of interest to the physical chemist as well as much that will be stimulating to the more technical reader A H Cook

Animal Behaviour

By Dr John Paul Scott (The College Library of Biological Sciences) Pp xi+281+16 plates (Chicago, Ill University of Chicago Press, London Cambridge University Press, 1958) 37*s* 6*d* net

THE particular value of this book is that it is comprehensible to reasonably intelligent people who have not steeped themselves in the jargon of the ethologists It may be used as a text-book because it covers well the general field of animal behaviour, especially in basic social aspects, but the book is also an introduction which will subtly draw the student forward into a wider range of reading The scientific discipline throughout is commendable

Animal behaviour is concerned with the activity of the whole organism and groups of organisms what an animal is doing is as important as what it is, and behaviour is one of the central problems of existence Dr Scott develops his work from the elements of behaviour, the limitations imposed by anatomy, and the internal causations from physiology, to the subject of learning and the effects of experience This is straightforward going with field and laboratory illustration, but when the study of organization of behaviour and social organization is reached Dr Scott becomes an inspiring teacher He is not to be classed with those practitioners in ethology who cannot see wood for trees he becomes a naturalist seeing individuals and populations in their larger environmental setting The problems of developing sociality and social disorganization in relation to ecological factors are well chosen and illustrated and the reader is left wondering—a valuable mental state—about the puzzling field of the gene complex in relation to homœostasy and habitat selection in very slightly different races of animals It is something of an achievement to write so simply without writing down F Fraser Darling

THE TANDEM GENERATORS OF THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

By K. W. ALLEN and F. A. JULIAN
Atomic Weapons Research Establishment, Aldermaston

W. D. ALLEN and A. E. PYRAH
Atomic Energy Research Establishment, Harwell

AND

J. BLEARS
Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester

THE electrostatic generator, associated with the name of Robert J. Van de Graaff, has emerged during recent years as one of the principal instruments in nuclear physics in the range 1–6 MeV. Its advantages are those of flexibility and precision. The type of ion accelerated (proton, deuteron, helium-3, etc.) and its energy can be readily varied, while at a given setting the beam energy can be controlled to 0·02 per cent. The principal limitation of the machine is that terminal voltages greater than 6 MV. are difficult to attain, and, until very recently, no electrostatic generator had produced hydrogen ions with energies in excess of 10 MeV. As a result, studies of nuclei using electrostatic generators have been limited to the lighter- and medium-weight elements. With energies of 12–14 MeV., these studies can be extended to the heaviest elements.

The idea of utilizing the principle of charge-changing to obtain doubling of energy in an accelerator is due to W. H. Bennett, who patented the idea about twenty-two years ago. Renewed interest was shown in the proposal following an article written in 1951 by Alvarez[1], who pointed out many of the advantages associated with voltage-doubling, and an important contribution was made by Weinman and Cameron[2], who developed an ion source which yielded 25 μamp. of negative hydrogen ions.

Briefly, the tandem generator[3,4] depends on the voltage multiplication which can be achieved by injecting negative ions into an electrostatic generator in which the stack, instead of being single-ended as in a conventional machine, extends throughout the length of the pressure vessel. The negative ion source is thus at earth potential and outside the pressure vessel, a factor which is of importance, as we shall see below. Negative ions are conveniently formed by the passage of positive ions through gases at velocities corresponding approximately to the velocities of the outer orbital electrons. These conditions favour the formation of negative ions ; at energies of 10 keV., for example, a hydrogen ion beam passing through hydrogen gas can emerge with 2 per cent in the form of H^-. Unwanted particles, such as neutrons and electrons, are removed from the negative ion beam by the action of a weak magnetic field before injection into the electrostatic generator. The beam is then

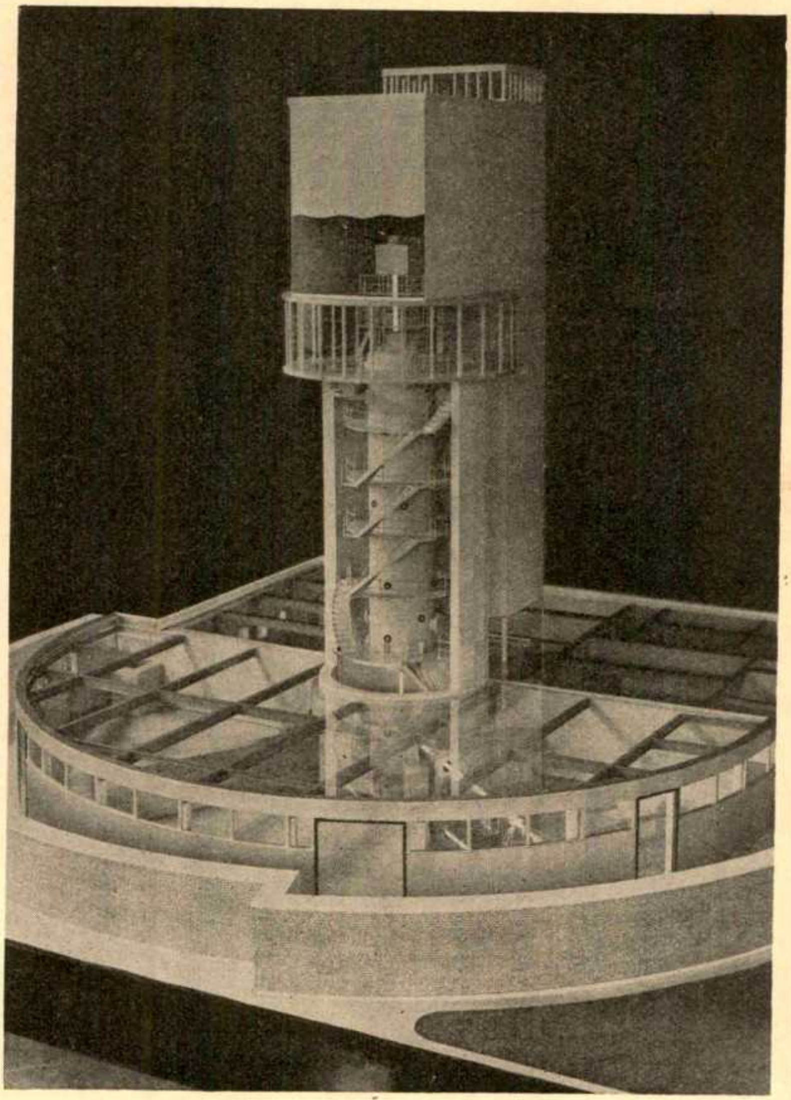


Fig. 1. Model of the tandem generator building at the Atomic Energy Research Establishment, Harwell

accelerated by the positive voltage on the central electrode, and as a result of this acceleration, the ions are moving with a centre of mass velocity large compared with that of the outer electrons about the nucleus. In these circumstances, the passage of the ion beam through a thin foil or tube containing gas at low pressure causes electrons to be stripped off, so that the emergent beam consists of positively charged particles. The energy lost by the beam in passing through the stripper is negligible ($<0{\cdot}5$ keV.). The positive ions are then further accelerated through the second half of the stack. Thus, an H^- ion of charge e, injected into a stack with a central electrode of V volts, will emerge with energy of $2\,Ve$ electron volts. Oxygen ions which are injected as O^- and lose, for example, five electrons at the central electrode will finally emerge with an energy $6\,Ve$, and so on.

The tandem generator has many possibilities. Proton and deuteron beams with energies of ~12 MeV. and oxygen ions with energies of 30–40 MeV. can readily be obtained. In the more distant future, ion beams of helium, lithium, fluorine and any other element capable of forming negative ions (a criterion which includes about half the periodic table) may be produced. The fact that the ions are generated outside the pressure vessel at or near ground potential means not only that the source of most of the troubles in an electrostatic generator is readily accessible for maintenance, but also that there are virtually no limits to the power consumption, size and complexity of the injector system. Thus, millimicrosecond time of flight techniques, which are important in many experiments, are more readily applied in the tandem generator than in the conventional machines, since deflexion and bunching can be applied to the low-energy beam before injection. Finally, it may be possible in the future to polarize the nuclei of negative ions, and eventually to produce beams of accelerated polarized protons.

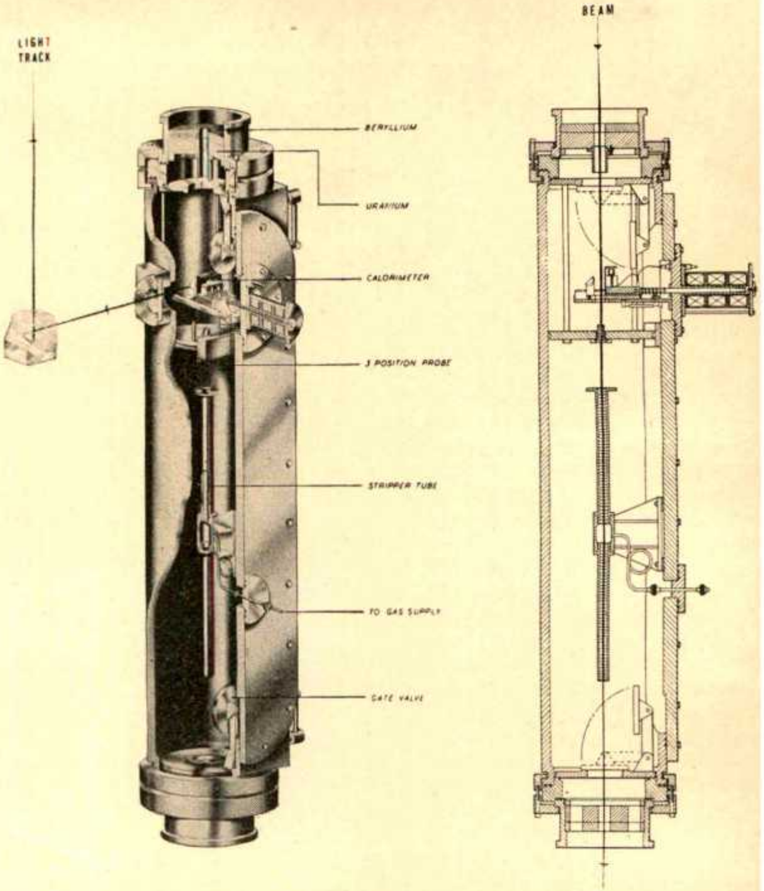


Fig. 2. Arrangement of the gas stripper used to convert negative ions into positive ions in the high-voltage terminal

A horizontal tandem generator has been developed by the High Voltage Engineering Corporation, of Burlington, Massachusetts, for the Chalk River laboratories of Canada, and came into operation in January of this year, following successful trials in Burlington. In 1956 interest in the tandem generator was growing in the United Kingdom Atomic Energy Authority, because the potentialities of the machine as a tool for nuclear research have a direct bearing on the atomic energy programme. Thus, precision studies of the energy-levels of the heaviest elements can for the first time be made with beams of protons or deuterons from the machine; similar studies can be made of the energy-levels and level densities in the region of the periodic table occupied by the fission products. Finally, the availability of high-energy deuteron beams makes possible neutron sources in the region of 8–12 MeV., a region which has hitherto constituted a gap in the energy of neutron sources readily available from conventional machines.

In June 1956, therefore, it was decided to build two machines for the Atomic Energy Authority, one at the Atomic Weapons Research Establishment, Aldermaston, and the other at the Atomic Energy Research Establishment, Harwell. A contract was placed with Metropolitan-Vickers, Ltd., for the engineering components of the British machines; the Atomic Weapons Research Establishment undertook the development of ion sources and strippers, while the provision of accelerating tubes was the responsibility of the Atomic Energy Research Establishment. A vertical design was chosen because there is no experience in Great Britain of the construction of horizontal machines, and it was felt that the engineering difficulties in a vertical machine would be less severe. There are, however, other advantages in a vertical design. In a vertical machine, a much greater weight of equipment can be placed in the centre terminal, so that the possibility presents itself of using the machine as a conventional single-ended machine as well as a tandem. Also, with a vertical machine, the beam can be delivered to any point in a horizontal plane by 90° deflexion in a single rotatable magnet. In Fig. 1 is shown a photograph of the model of the tandem generator at Harwell; the target rooms are disposed in a semi-circle, with two shielding walls dividing the area into three

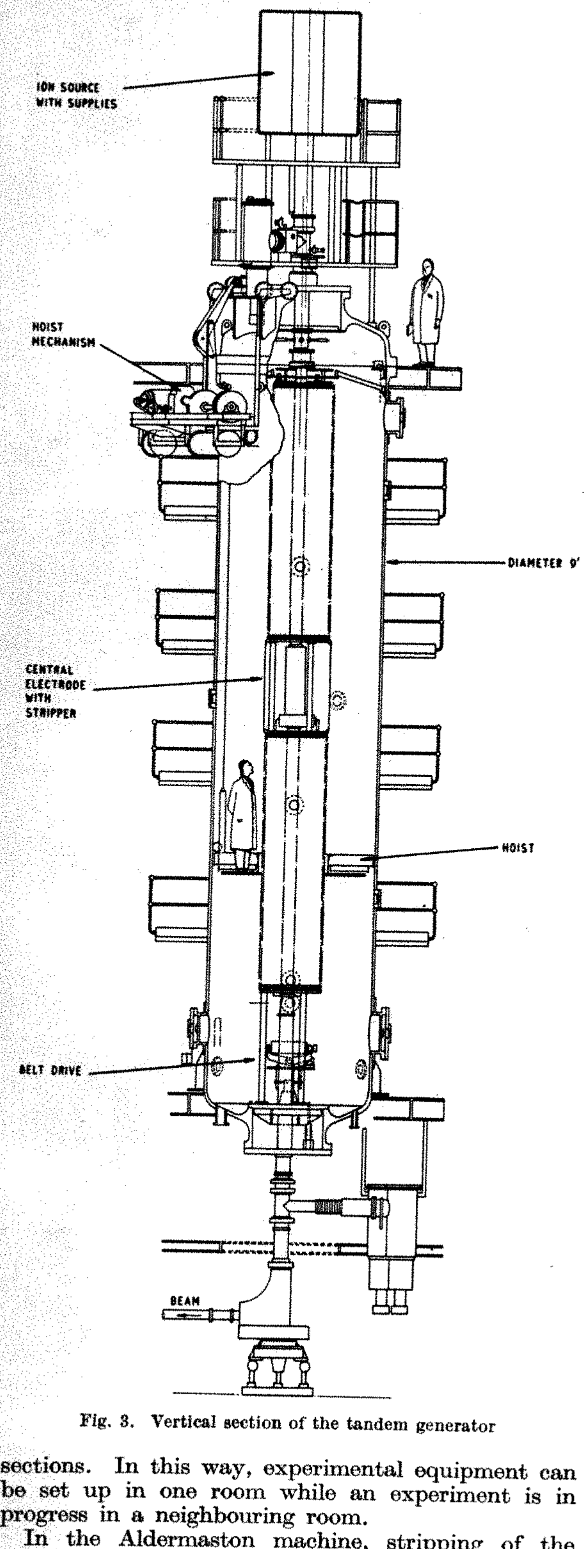


Fig. 3. Vertical section of the tandem generator

sections. In this way, experimental equipment can be set up in one room while an experiment is in progress in a neighbouring room.

In the Aldermaston machine, stripping of the negative ions in the centre terminal is achieved by passing the beam through a tube 24 in. long and 0·14 in. in diameter containing oxygen gas at low pressure. Precise control of the injected beam is required in order to maintain an accurate focus at the centre of the stripper tube for all centre terminal voltages in the operating range of the machine. The advantage of the gas stripper is its indestructibility; however, considerable success has been achieved at Harwell in stripping with thin carbon films 4–5 μgm./cm.[2] thick, and analysed proton beams up to 2 μamp. have been focused on targets. The components of either gas stripper or foil stripper are mounted on a flat plate which forms the greater part of one side of the aluminium alloy chamber (Fig. 2) which joins the two accelerating tubes. The type of stripper or any of its components may therefore be changed at will without affecting the overall alignment of the accelerator.

The injector system, which is described elsewhere[5], is based on a Thonemann ion source used in the manner first suggested by Phillips and Tuck[6]. It is essentially a positive ion source in which electron exchange with neutral atoms takes place in the exit canal. Lens voltages following the canal are reversed, as compared with the typical positive ion source, so that only negative ions emerging from the canal are accelerated. After magnetic analysis to remove electrons and unwanted ions, the ion beam from the source is further accelerated and focused by electrostatic lenses. It enters the first accelerating tube of the main machine with an energy in the range 40–120 keV., depending on the centre terminal voltage. An optical method, suggested by R. Middleton, of observing the beam in the centre terminal has shown that a focus about 3 mm. in diameter can be obtained.

Identical accelerating tubes each 14 ft. long are used in the two halves of the machine. The tubes consist of highly polished aluminium electrodes cemented to accurately ground-glass rings. As in the Chalk River machine[3], the bulk of the gas used in stripping is pumped down the lower accelerating tube. This minimizes the loss of negative ion beam due to charge neutralization in the upper tube.

The engineering of the machine, which will be described elsewhere, is shown in section in Fig. 3. The pressure vessel is 45 ft. long, weighs 45 tons, and when fully pressurized contains about 2 tons weight of nitrogen mixed with carbon dioxide or freon. Access to the machine for general servicing is by the manholes at the base, from which personnel can be hoisted by a lift with driving mechanism situated outside the pressure vessel near the top.

The accelerators at both Establishments have been operating satisfactorily for several months. Proton and deuteron beams with energies up to 11·5 MeV. have been used in experiments, and currents up to 8 μA. at somewhat lower energies are also available.

We wish to express our gratitude to our many colleagues in Harwell, Aldermaston and Metropolitan-Vickers who have contributed to the success of these machines. In particular, we should like to mention A. J. Marriott, J. R. Henry and F. A. Howe of Aldermaston, R. H. V. Dawton and J. H. Partridge of Harwell, and G. W. C. Cogle and J. Roxburgh of Metropolitan-Vickers.

It is also a pleasure to acknowledge the support and encouragement we have received at all times from Sir William Cook and Mr. D. W. Fry, of the Atomic Energy Authority, and the Directors of Metropolitan-Vickers.

[1] Alvarez, L., *Rev. Sci. Instr.*, **22**, 705 (1951).
[2] Weinman, J. A., and Cameron, J. R., *Rev. Sci. Inst.*, **27**, 288 (1956).
[3] Danforth, J. L., *Can. Elec. Eng.*, 18 (July 1958).
[4] Allen, W. D., *Can. Elec. Eng.*, 26 (February 1959).
[5] Collins, L. E., and Riviere, A. C., *J. Nuc. Inst.*, **4**, 121 (1959).
[6] Phillips, J. A., and Tuck, J. L., *Rev. Sci. Inst.*, **27**, 97 (1956).

UNIVERSITY OF MALAYA IN KUALA LUMPUR

By PROF. R. D. PURCHON
Professor of Zoology, University of Malaya at Singapore

WITHIN less than ten years from its foundation (October 8, 1949) the constitution of the University of Malaya has been radically altered by ordinances enacted by the Governments of the Federation of Malaya and of the Colony of Singapore. The chief purpose of these enactments was to create a new Division of the University at Kuala Lumpur in the Federation of Malaya. The new constitution came into effect on January 15, 1959, and the University now comprises three bodies.

The University of Malaya (chancellor, the Right Hon. Malcolm MacDonald; vice-chancellor, Dr. A. Oppenheim). The main functions of the University of Malaya are the maintenance of co-ordination between the two Divisions, and the conferment of degrees. The authorities are the Court, the Central Council and the Guild of Graduates.

The University of Malaya in Singapore (principal, A. A. Sandosham). The authorities are the Divisional Council and the Divisional Senate. This Division of the University continues to function as before, except for the transfer to the newly created Division at Kuala Lumpur of the Departments of Geology and Engineering and of certain Departments in the Faculty of Arts.

The University of Malaya in Kuala Lumpur (principal, F. Mason). This is similarly administered by a Divisional Council and a Divisional Senate, and is accorded equal status with the establishment in Singapore. This Division comprises Faculties of Arts, Science and Engineering, while the Department of Agriculture will doubtless be accorded the status of a faculty in the space of a few years. The Department of Engineering was transferred as a whole from Singapore a year ago, and is now fully developed in new buildings in the Pantai valley at Kuala Lumpur. The Department of Geology is in the process of moving, only first-year students being taught in Kuala Lumpur during the present session; when the move has been completed, this subject will cease to be taught at Singapore, thus diminishing the diversity of subjects taught in the University of Malaya in Singapore. However disappointing this may be, this rationalization is unavoidable, at least in the early years under the new constitution.

Development of the University site in the Pantai valley at present includes the completed buildings of the Faculty of Engineering, one residential college and an estate of staff houses. Plans are already at an advanced stage for the buildings for the Faculties of Arts and Science and for the Department of Agriculture. Although these buildings will not be completed for a year, students have been enrolled into the 'intermediate year' of the science course and teaching has begun with skeleton staffs in temporary quarters in a local school, the Victoria Institution.

The Asia Foundation has made a most generous offer of help regarding the provision of a nucleus of books for the library at Kuala Lumpur. Consideration is being given by the University authorities to the methods whereby the books and journals in the library at Singapore can be made available to students in Kuala Lumpur, but care must be taken to ensure that the one excellent library is not split into two mediocre ones.

Appointments to the newly created chairs in science subjects are as follows:

Agriculture. The creation of a Faculty of Agriculture at the present time has been made possible by the generosity of the Government of New Zealand, which provided £NZ250,000 specially for this purpose under the Colombo Plan Technical Co-operation Scheme. It is therefore a happy circumstance that the first professor of agriculture should himself be a New Zealander. Prof. G. M. Davies, who was born in Dunedin, graduated at the University of Otago and Massey Agricultural College and then spent a further year at Canterbury Agricultural College. During the Second World War he served with the Royal New Zealand Air Force, and won the Distinguished Flying Cross in 1942. After the War, Mr. Davies worked for three years in New Zealand, first as a farm appraiser with the State Advances Corporation and then as senior lecturer in soils and fertilizers at Massey Agricultural College. In 1948 Mr. Davies moved to the United Kingdom, where he remained for ten years as a regional grassland husbandry officer in the National Agricultural Advisory Service.

Botany. Prof. M. E. D. Poore, the first incumbent of the chair of botany, brings to the newly created Department several years of ecological experience. Graduating from the Botany School at Cambridge, Dr. Poore gained his doctorate in 1954. He studied for a time with Braun-Blanquet in the Montpellier School and then joined the Nature Conservancy at Edinburgh, where he initiated a survey of Scottish mountain vegetation, for which he is well known. He then joined Hunting Technical Services as a consultant ecologist and spent some three years in the Middle East. Here, Dr. Poore surveyed the soils, vegetational units and agriculture of Cyprus, Jordan and Iraq with the view of outlining potentialities for agricultural development in these countries.

Chemistry. The University of Malaya in Kuala Lumpur is fortunate indeed to have been able to attract Prof. R. A. Robinson to this important appointment. Prof. Robinson graduated at the University of Birmingham, where he was awarded the degree of Ph.D. in 1929, and the degree of D.Sc. in 1936. Dr. Robinson held a Commonwealth Fund Fellowship at the University of Pennsylvania and at Yale University, and then held a Sterling Research Fellowship at Yale. Dr. Robinson had appointments at University College, Exeter, and at Auckland University College until the Second World War. During most of the war years he held a senior post in a Chemical Warfare Department. In 1948 he was appointed to the chair of chemistry at the University of Malaya (in Singapore) and holds that post until he returns from a period of study-leave abroad to take up his new appointment in Kuala Lumpur. During his years at Singapore, Prof. Robinson has served a full tour of duty as dean of science, and has also served for a period as acting vice-chancellor. He will therefore bring to Kuala Lumpur an invaluable store of administrative experience. Prof. Robinson is best known for his research in the field of electrochemistry, and is the author of a standard monograph in this subject.

Geography. Prof. Robert Ho, who has been appointed to the chair of geography in the University of Malaya in Kuala Lumpur, graduated from King's College, London. He was awarded the degree of M.A. in the University of London in 1950. He has studied soil survey at Rothamsted, and soil analysis in the Department of Agriculture at Oxford. He was appointed to the staff of the Department of Geography in the University of Malaya (in Singapore) in 1948 and has been acting head of that Department from 1957 until his present preferment.

Mathematics. The University of Malaya in Kuala Lumpur is fortunate in recruiting Prof. C. J. Eliezer to the chair of mathematics. Prof. Eliezer is of Ceylonese nationality; he graduated from the Department of Mathematics at Cambridge, was awarded the degree of D.Sc. in the University of London, and has occupied the chair of mathematics at the University of Ceylon since 1949. He is a mathematical physicist who is best known for his fundamental research in the field of quantum mechanics. Having served for three years as dean of science in the University of Ceylon, Prof. Eliezer will have much experience to offer in the development of the new Faculty of Science at Kuala Lumpur.

Zoology. Prof. J. R. Hendrickson, who has been appointed to the chair of zoology, was trained at the University of Arizona and at the University of California at Berkeley, and joined the staff of the University of Malaya (in Singapore) in 1951. He is a vertebrate zoologist with wide experience and with special interests in herpetology and ecology. His study of the biology of the green sea turtle will doubtless become known as a classic example of objectivity in field research under difficult conditions. His practical experience of the fauna of the Malayan jungle will enable him to endow his Department with an appropriate trend in teaching and research, while his fluency in colloquial Malay will make him specially acceptable in this virile and newly emergent country.

CONTINUOUS-FLOW CULTURE OF THE FILAMENTOUS MOULD *PENICILLIUM CHRYSOGENUM* AND THE CONTROL OF ITS MORPHOLOGY

By S. J. PIRT and D. S. CALLOW
Microbiological Research Establishment, Ministry of Supply, Porton

In a recent report[1] we described the application of continuous-flow technique[2] to culture of the mould *Penicillium chrysogenum*, which is used for penicillin production. This technique has now been used by us to elucidate the influence of *p*H value on the morphology of *P. chrysogenum* in submerged culture. The morphology of the mould is considered to be of importance in the process of penicillin production[3]. The role of agitation in determining the morphology of the mould has been stressed by Duckworth and Harris[4] and by Dion, Carilli, Sermonti and Chain[3]; but so far the influence of *p*H value on the morphology has remained unknown. The elucidation of the influence of *p*H value has been made possible by the advent of reliable means for the accurate control of *p*H value in cultures over long periods[5].

Aberrant Forms of Fungi in Submerged Culture

One of the problems of continuous-flow culture which we encountered was that the mycelia of newer strains of the mould (*Wis* 49–133 and *Wis* 54-1255) selected for high penicillin production grew initially in a filamentous form but after a time in continuous culture the pellet form of growth was obtained. The main morphological differences between the filamentous and the pellet types of mycelium can be seen by reference to Figs. 1*a* and 3. The pellet type of mycelium was undesirable because with it steady-state growth, that is, a constant mycelium concentration in continuous culture, could not be maintained, and also its rate of penicillin production was much lower than that of the filamentous form.

Camici, Sermonti and Chain[6] showed that, in batch cultures, the mycelium develops in the pellet form if the inoculum is below a certain size; but in our experiments the inoculum was sufficiently large to ensure that the mould grew in the filamentous form until after the maximum dry-weight concentration was reached.

We found that pellet formation was linked with the production of swollen, distorted, short hyphæ, which mark an aberrant form. Duckworth and Harris[4], in their observations on the production of this aberrant form, included a series of references which emphasized that agitation played a part in the process. The production of short, swollen hyphæ in vigorously agitated cultures of *P. chrysogenum* under penicillin-producing conditions was confirmed by Dion *et al.*[3], who attributed it to mechanical damage caused by the shearing action of stirring.

It does not seem to have been pointed out previously that abnormally short, much-branched, swollen hyphæ similar to those found to be characteristic of agitated cultures of *P. chrysogenum* have also been found to occur in unagitated cultures of fungi under some conditions. Foster[7], in a short review of this aberrant form, gives references to it going as far back as 1857. Pasteur (quoted at length by Foster[7]), Wehmer[8], Frey[9] and Sakamura[10] have reported the production of this aberrant form by *Mucor*, *Penicillium* and *Aspergillus* species. The many different conditions, for example, lack of oxygen or high acidity, considered necessary for the formation of these abnormal cells have been summarized by Foster[7].

In this article we describe how to produce in a vigorously agitated culture of *P. chrysogenum* either the normal, long, thin hyphæ or the short, swollen type, and also how to prevent pellet formation in continuous culture. The importance of control of morphology in continuous-flow cultures and in aeration is discussed.

Continuous-flow Culture Method

Cultures were grown in a continuous-culture apparatus developed from the type described by

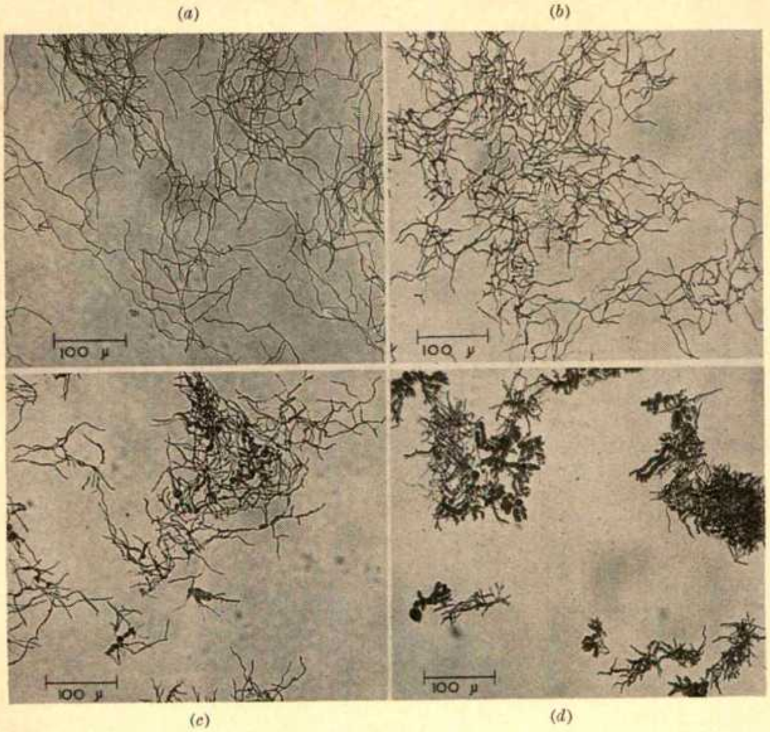


Fig. 1. Mycelial forms of strain *Wis* 54-1255 in cultures grown at different *p*H values. (*a*) *p*H 6·0; (*b*) *p*H 6·5; (*c*) *p*H 6·9; (*d*) *p*H 7·4

Elsworth, Meakin, Pirt and Capell[11]. The *p*H control system was as described by Callow and Pirt[5]. The composition of the medium was (amounts in gm./l.): crystalline magnesium sulphate, 0·25; ferrous sulphate, 0·10; copper sulphate, 0·005; zinc sulphate, 0·02; sodium sulphate, 0·50; manganese sulphate, 0·024; calcium chloride, 0·075; ethylenediamine tetraacetic acid, 0·566; dihydrogen potassium phosphate, 2·0; ammonium sulphate, 6·15; glucose, 20·0; phenylacetic acid, 1·0. The *p*H value was adjusted with sodium hydroxide. In the inoculum culture, which was seeded with spores, phenylacetic acid was excluded from the medium and the glucose concentration was 10 gm./l. Growth was limited by the amount of glucose supplied. There was an excess of available oxygen. Vortex aeration was used with a stirrer speed of 1,200 r.p.m.; the impeller diameter was 0·42 times the vessel diameter; the volume of culture in the vessel was 1·7 l. An antifoam agent ('Alkaterge-*C*' (Commercial Solvents, Terre Haute, U.S.A.) 30 per cent (v/v) in liquid paraffin) was added periodically to the cultures at a rate of 0·1 ml. every hour. The temperature was 25°. The dilution rate (flow rate/culture volume) was 0·05 hr.$^{-1}$, so that the average residence time of the mycelium in the culture was 20 hr. The duration of culture varied from 200 to 2,000 hr. Changes in *p*H value were made at a rate of 0·1 *p*H units/hr. for the reason given elsewhere[12], and where, also, additional details of the continuous-culture method may be found.

The mycelium was stained with cotton blue for the photomicrographs.

Morphological Observations

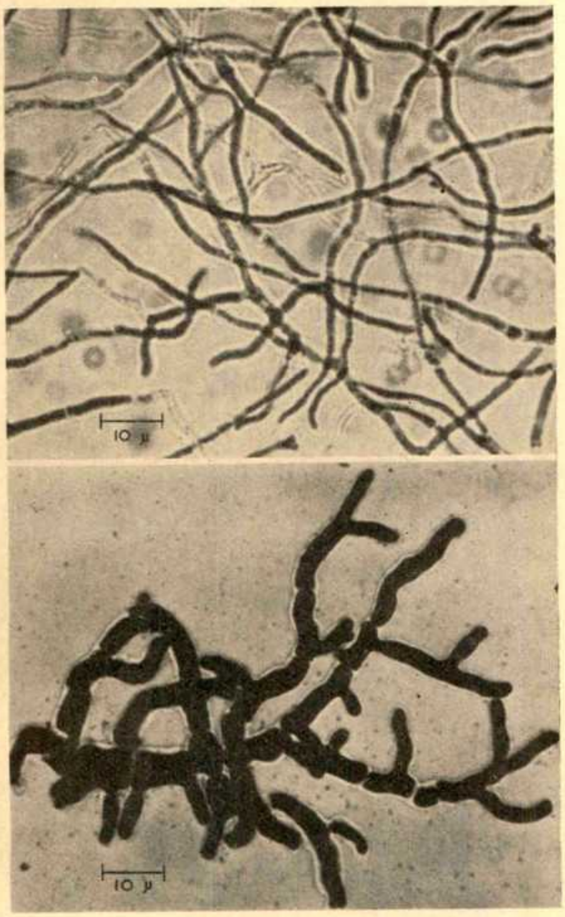
During the initial batchwise growth before flow was started, the mould grew in the filamentous form until the dry-weight concentration was near the maximum, 0·9 per cent (w/v). Then continuous flow was started and the *p*H value, which initially was 7·0, was raised to 7·4 in order to bring it near the optimum for penicillin production. Under these conditions, for about the first 100 hr., steady-state growth was obtained and the dry weight remained at the maximum value. The mycelium form was of the aberrant filamentous type described by Dion *et al.*[3]. The aberrant filamentous form is illustrated in Figs. 2*b*, 4*a* and 1*d*. The characteristics of the aberrant form were the presence of short, much-branched, swollen and often distorted hyphæ. For comparison, the normal filamentous type is shown in Fig. 1*a*. The normal type is characterized by long, thin hyphæ of constant thickness and few branches.

After about 100–200 hr. in continuous-flow culture at *p*H 7·4, strains *Wis* 49–133 and *Wis* 54–1255 began to form pellets of mycelium and gradually, during a further 100 hr., the aberrant filamentous form gave place almost entirely to the pellet form. The initiation of pellet formation seemed to be agglutination of the hyphæ within the individual fragments of mycelium. When the mycelium was completely in the pellet form it sedimented like a suspension of sand grains. The pellets resembled the sclerotic type described by Thirumalachar and Gopalkrishnan[13].

The strains differed in their ability to form pellets. Although all three strains investigated formed the aberrant, filamentous type of mycelium under the conditions stated, strain *Wis* 47-1564, unlike its descendant strains *Wis* 49-133 and *Wis* 54-1255, formed pellets only to a small extent and those that were formed did not persist more than about 100 hr.

We discovered, first with strain *Wis* 47-1564 and confirmed later with strain *Wis* 54-1255, that pellet formation and the formation of the aberrant and normal filamentous forms were determined by the *p*H value of the medium. The influence of *p*H value on the morphology of the mould may be seen in Fig. 1, which shows the appearance of the mycelium grown at *p*H values 6·0, 6·5, 6·9 and 7·4. The average length of branches decreased progressively from the order 200μ at *p*H 6·0 to 20μ at *p*H 7·4. The thickness of hyphæ was 2–3μ at *p*H 6·0, but at 7·4, owing to the formation of swollen cells, the thickness covered the wider range, 2–18μ. Fig. 1*d* shows the large number of swollen, yeast-like cells produced at *p*H 7·4 and also the beginning of pellet formation. Pellet formation was most marked at *p*H 7·4 but it did occur to a lesser extent at *p*H values down to *p*H 6·7 with strain *Wis* 54-1255.

Lengthening of the hyphæ resulted in a marked increase in the viscosity of the culture. The culture produced at *p*H 6·7 and higher values flowed easily like a bacterial culture, whereas the culture grown at *p*H 6·0 had a porridge-like consistency and flowed with difficulty. The dry weights of mycelium in the culture were the same at all *p*H values.



(a)

(b)

Fig. 2. Normal and aberrant types of mycelium of strain *Wis* 47–1564. (*a*) Long thin hyphæ (normal type) produced by growth at *p*H 6·0; (*b*) short hyphæ containing swollen cells (aberrant type) produced by growth at *p*H 7·4

The changes in morphology and viscosity accompanying change in *p*H value were reversed when the *p*H change was reversed, so that, for example, the pellet or short filamentous form gave place to the long filamentous form when the *p*H value was lowered and vice versa. Microscope observations showed that the new form of mycelium produced as a result of a *p*H change arose by new growth from the old form: it was not a transformation of the old form. This was confirmed by the fact that the rate of appearance of the new form was approximately equal to the growth-rate; after a *p*H change it took about three days for the old form to disappear almost completely.

The *p*H value was not the only factor which affected hyphal length and morphology; nutrition also was shown to be a controlling factor. Substitution of the nitrogen source, ammonium sulphate, by corn-steep liquor (filtered, 4·5 per cent (v/v)), which is a common constituent of the media used in penicillin production, increased the hyphal length, reduced the frequency of hyphal branching and prevented the formation of swollen cells at *p*H 7·4. The effect of addition of corn-steep liquor is shown in Fig. 4. These results strongly suggest that corn-steep liquor contains some substance which stimulates the production of the normal morphological type.

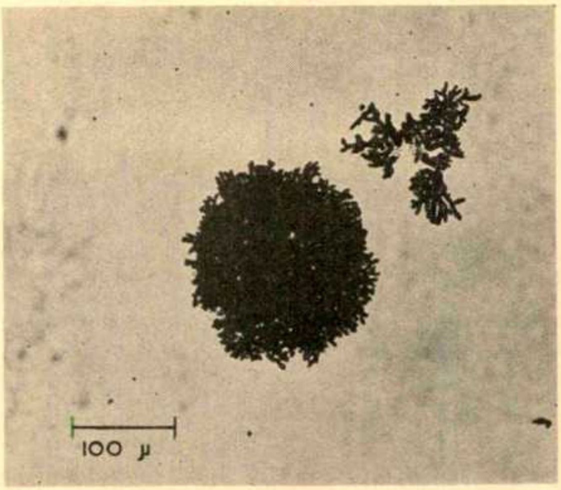
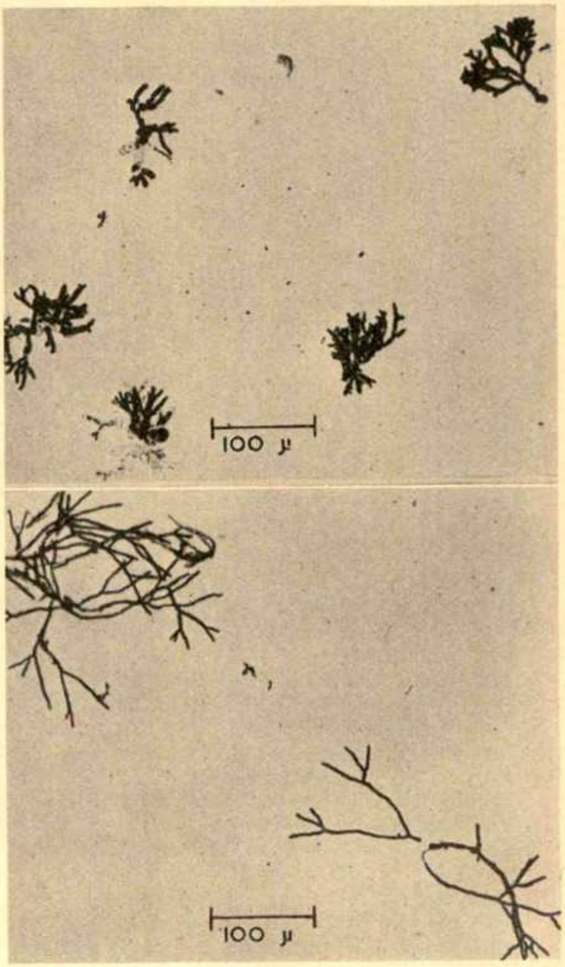


Fig. 3. Pellet mycelium of strain *Wis* 49-133 produced at *p*H 7·4



(a)

(b)

Fig. 4. Mycelium of strain *Wis* 49-133 grown at *p*H 7·4. (*a*) With ammonium sulphate as the nitrogen source; (*b*) with corn-steep liquor as nitrogen source

Conclusions: Possible Role of Cell Wall

The conclusions we draw are that: during growth of *P. chrysogenum* in agitated culture the hyphal length decreases with increase in the *p*H value above

6·0; the hyphal length is a minimum at pH 7·0–7·4 and higher values. Extensive formation of swollen cells occurs at pH values above 7·0, this property and the hyphal length being influenced by the medium composition. Pellet formation occurs at pH values above 6·7 but it also shows dependence on strain.

The increase in the length of hyphæ with decrease in pH value we interpret to mean that the resistance of the cells to shear increases with decrease in pH value. We attribute the varying resistance to shear and the production of swollen cells to variation in the cell-wall structure. This idea was suggested to us by the recent bacterial studies which have shown that the mechanical strength of a bacterial cell resides in its cell wall, and by analogy we suppose that the resistance of the fungal cell to mechanical forces is determined by its cell-wall structure. This hypothesis implies that the cell-wall structure or composition depends on the pH of the environment during growth. Also swollen cells could be due to a change in cell-wall structure involving loss of rigidity and consequent inability to resist the internal osmotic pressure.

From the practical point of view the long hyphæ produced at a low pH value are undesirable because they make the viscosity of the culture high and consequently lower the efficiency of mixing and rate of transfer of oxygen[14]. On the other hand, to prevent the extensive formation of pellets and the swollen aberrant form, the pH value during growth should not be greater than 7·0.

Since the optimum pH value for penicillin production is about 7·4 it seems likely that a continuous-flow process for penicillin production will require two stages, the first stage for growth of the mould with the pH value not exceeding 7·0 and a second stage with a higher pH value for penicillin production[15].

We are grateful to Prof. M. P. Backus of the University of Wisconsin for the gift of strain *Wis* 54-1255. Strains *Wis* 47-1564 and *Wis* 49-133 were obtained from the National Collection of Industrial Bacteria, Department of Scientific and Industrial Research, Teddington. The technical assistance of Mr. J. E. D. Stratton is gratefully acknowledged.

[1] Pirt, S. J., and Callow, D. S., "The Continuous Culture of *Penicillium chrysogenum*", read at meeting of the Society of Applied Bacteriology, January 14, 1959 (to be published).

[2] Herbert, D., Elsworth, R., and Telling, R. C., *J. Gen. Microbiol.*, **14**, 601 (1956).

[3] Dion, W. M., Carilli, A., Sermonti, G., and Chain, E. B., *R.C. Ist.*, sup. Sanit., English ed., **17**, 187 (1954).

[4] Duckworth, R. B., and Harris, G. C. M., *Trans. Brit. Mycol. Soc.*, **32**, 224 (1949).

[5] Callow, D. S., and Pirt, S. J., *J. Gen. Microbiol.*, **14**, 661 (1956).

[6] Camici, L., Sermonti, G., and Chain, E. B., *Bull. World Health Org.*, **6**, 265 (1952).

[7] Foster, J. W., "Chemical Activities of Fungi", 298 (Academic Press, New York, 1949).

[8] Wehmer, C., *Ber. deutsch. bot. Ges.*, **31**, 257 (1913).

[9] Frey, A., *Rév. Gén. Bot.*, **39**, 277 (1927).

[10] Sakamura, T., *J. Fac. Sci. Hokkaido Imper. Univ.*, Series V, **1**, 1 (1930).

[11] Elsworth, R., Meakin, L. R. P., Pirt, S. J., and Capell, G. H., *J. App. Bact.*, **19**, 264 (1956).

[12] Pirt, S. J., and Callow, D. S., *J. App. Bact.*, **21**, 188 (1958).

[13] Thirumalachar, M. J., and Gopalkrishnan, K. S., *R.C. Accad. Lincei*, **14**, 691 (1953).

[14] Solomons, G. L., and Perkin, M. P., *J. App. Chem.*, **8**, 251 (1958).

[15] Provisional Patent Application 13693/59 on April 22, 1959.

TRANSLOCATION OF COBALT-60 AND CÆSIUM-137 BY FUNGI IN AGAR AND SOIL CULTURES

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A LONG-TERM research project has been initiated at the Grassland Research Institute on the mechanism of microbial decomposition of grass swards after ploughing back into the soil. These investigations comprise, among others, studies on the manner by which saprophytes progress through the soil from one food-base, that is, an aggregate of plant debris, to another. This will be determined by the phase in which the fungus exists in the soil—whether as dormant spores and resting bodies or as an actively growing, progressive mycelium. In this connexion the mechanism of translocation of nutrients by fungi growing in the soil requires elucidation.

Translocation is the movement of nutrients and other materials from one part of the plant to another. As regards higher plants the mechanism of translocation has been studied extensively; but for fungi comparatively little work has been published. Buller[1] investigated protoplasmic streaming in fungi. On the basis of his own work and that of others he concluded that this phenomenon was the principal agent of translocation of nutrients in fungi. Schütte[2], after studying translocation by means of dyes and fluorescein, postulated that fungi can be divided into two groups, translocating and non-translocating, and he, too, associated translocation with protoplasmic streaming. The work of Melin and Nilsson[3,4] and that of Harley and his collaborators[5,6] on the transfer of nutrients into the host by means of mycorrhiza indicates a translocation mechanism via the mycelium.

Preliminary notes have been published by Grossbard and Stranks[7-9] on their attempt to study the growth of soil fungi *in situ* by inoculating soil with a fungal culture labelled with a nuclide emitting gamma-rays. It was hoped that those fungi which produce hyphæ in the soil would form a fresh mycelium growing out from the radioactive inoculum. The new hyphæ would in turn become radioactive and their distribution could be detected by virtue of the gamma radiations which have the power to penetrate the soil. This technique would depend primarily on the translocation of the nuclide from the radioactive inoculum into the new hyphæ, and could provide not only a useful research tool for tracing the growth of fungi in the soil but also help to elucidate the mechanism of transport of nuclides through the soil via fungal hyphæ. This work has been extended and a brief account is given here.

The fungi used in the latest studies were *Pellicularia filamentosa* (Pat.) Rogers (*Rhizoctonia solani*) kindly supplied by Dr. S. D. Garrett ; *Helminthosporium sativum* Pamm, King and Bekke, kindly supplied by Dr. J. H. Western ; *Phycomyces blakesleeanus* Burgeff Herb. Imp. Mycol. Inst. 44142 ; *Phytophthora cactorum* (Leb. and Cohn) Schroet. Herb. Imp. Mycol. Inst. 62471 ; *Rhizopus stolonifer* (Ehrenb. ex. Fr.) Lind. Herb. Imp. Mycol. Inst. 42844.

The nuclides used were cobalt-60 and cæsium-137. They were chosen because they emit γ-photons in addition to β-particles. The fungi were labelled by culturing in media containing the nuclides (1 μc/ml.), which were readily taken up by the mycelium[10]. When grown in broth cultures, 25–50 per cent activity (varying with the conditions of the experiment) could be detected in the total mat after thorough washing.

The main test organisms for the soil cultures were *P. filamentosa* and *R. stolonifer*. Glass tubes filled with sterile soil were used, though occasionally also rectangular boxes. The inoculum for the soil-growth tubes consisted of a number of disks of a radioactive agar culture mixed with soil. This was divided into two halves of approximately equal activity, one of which was killed by heat. Each half was then placed at one end of the soil column in a growth tube. From this inoculum γ-rays were emitted which penetrated the soil. Immediately after incorporation of the radioactive mycelium (living or killed) the tubes were scanned with a directional scintillation counter with a collimator (Ekco model *N* 559*A*). This initial measurement served as a standard to check whether migration of the radioisotope via the fungal mycelium occurred after inoculation and to what extent the radioactive inoculum contributed to the counting-rate as observed at points away from the initial reference source. The figures in Table 1, columns 1 and 3, referring to *P. filamentosa* cultures show that the highest counting-rate outside the wall of the tube was just above the point where the radioactive mycelium had been incorporated. A similar observation was made with *R. stolonifer* and also with *Phytophthora cactorum*. The inoculum of the latter labelled with cobalt-60 was buried several cm. deep in soil in a box and the preliminary scan was performed laterally and longitudinally. In soil-box cultures of *H. sativum* labelled with cæsium-137 the greatest number of counts was also obtained just above the inoculum. This method is useful and can locate with considerable accuracy the position of a radioactive inoculum through soil and the lid and wall of the container.

After inoculation, the growth tubes were incubated and counts were made at weekly intervals. Columns 2 and 4 in Table 1 show the counts after 3 weeks. No significant change in counting-rate could be observed as compared with the first scan. Also the ratio of activity between 'living' and 'dead' inoculum tube was the same after 3 weeks. However, by that time a fresh mycelium had grown out which could be seen to penetrate the entire soil column. This was particularly evident in the *Pellicularia* culture. However, radioactivity could not be detected in this fresh growth. Similar observations were made with the fungi which were inoculated into soil boxes. The failure to detect any radioactivity in the fresh mycelium by scanning with the scintillation counter may have been due to one of three causes. First, the fungi tested lacked the capacity to translocate cobalt-60 or cæsium-137 ; second, the scanning technique with the scintillation counter was inadequate ; and third, the dilution of radioactivity by the outgrowing hyphæ was so great that insufficient activity was produced in the volume being scanned to enable detection.

Table 1. SCANNING RESULTS OF SOIL GROWTH TUBE OF *Pellicularia filamentosa* (Co-60)

Distance from inoculum (cm.)	Counts/sec. Living (1) Initial	Counts/sec. Living (2) After 3 weeks	Counts/sec. Killed (3) Initial	Counts/sec. Killed (4) After 3 weeks
0	800	800	780	780
2	300	320	300	285
4	140	150	145	140
6	90	90	92	84
8	70		66	
10	56	52	55	56
12	46		44	
14	40	39	37	36
20	23		22	
26	16	16	15·5	16·5
32	11·5		12·5	
38	9·5	9·5	9·0	9·6
44	7·4		7·4	
50	6·5	6·6	6·5	6·5

The counts were recorded on a ratemeter Ekco type *N*522 and include background counts of 2·5/sec.

Regarding the first point no information could be found in the literature on whether fungi in general are capable of translocating cobalt-60 or cæsium-137 in a manner similar to that reported for higher plants as regards cæsium-137[11] and cobalt-60[12]. It was therefore necessary to study translocation in fungi in agar and broth cultures.

Beginning these studies with *P. filamentosa* the transport of cobalt-60 from submerged into aerial mycelium was studied by autoradiography employing Pelc's[13] stripping film technique. Cobalt is often considered to be a microbial toxin. However, the addition of cobaltous chloride to the medium—whether as the stable or the radioactive isotope—enhanced the growth of *P. filamentosa*. Details of the experimental technique were described by Grossbard[10], who suggested that accumulation of cobalt-60 occurred inside hyphæ submerged in radioactive agar, for as the autoradiograms showed, the density of silver grains inside the hyphæ was greater than in the agar film between the mycelium. Yet, in autoradiograms of aerial mycelium growing just above the active submerged mycelium the grain density within the aerial hyphæ was similar to that of the background. This suggested that the tracer was not transported into the aerial hyphæ. Similar negative results were obtained from aerial mycelium in broth cultures. It was therefore at first believed that *P. filamentosa* inherently lacked the capacity for transporting cobalt-60 through its system and was one of the group of fungi which—after Schütte[2]—had no translocation mechanism[7,8]. However, when using the stripping film technique very thin preparations have to be made and a few hyphæ only were used. The absence of silver grains in the aerial mycelium may have been due merely to the fact that the dilution of the nuclide when transported from the submerged into the aerial hyphæ was so great that not enough tracer was available for a positive autoradiogram to be formed. That this reasoning was correct was shown when an autoradiogram was produced of large quantities of mycelium placed on an X-ray film. Adapting a technique described by Schütte[2], a small dish of agar containing cobalt-60 was placed

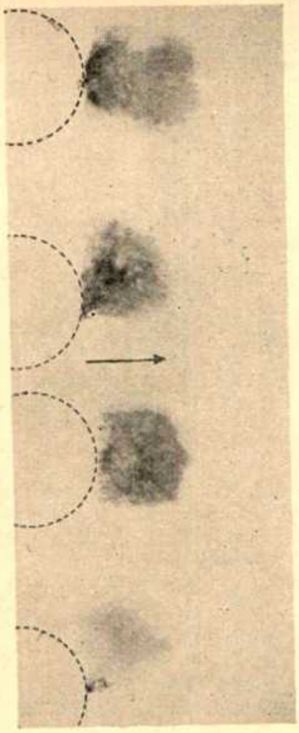

Fig. 1. Autoradiogram of *Pellicularia filamentosa*, 'Cellophane' strips + mycelium

Ↄ Original outline of container (diagrammatic) with agar + cobalt-60 and inoculum of fungus

Arrow indicates inactive agar with fresh mycelium which became labelled with cobalt-60

Gradual decrease in intensity of blackening with increase in distance from active container

inside a large one filled with similar but inactive agar. In the centre of the radioactive dish *P. filamentosa* was inoculated. The mycelium grew out of the dish over the glass edge on to some 'Cellophane' strips situated on top of the inactive agar of the outer container. The strips together with the mycelium were removed and fixed on microscope slides which in turn were placed in close contact with an X-ray film 'Industrial *B*' (Ilford). After exposure for 3 weeks a clear image of the mycelium developed, suggesting translocation of cobalt-60 from the inner container via the mycelium (Fig. 1). The blackening was most intense at the points where the 'Cellophane' strips were nearest to the container with the radioactive agar and decreased in intensity with an increase in distance. However, when tufts of hyphæ were removed from the 'Cellophane' strips at intervals of 5 mm. the resulting autoradiograms were negative. These observations indicate that a translocation mechanism for cobalt-60 and probably other materials does occur in *P. filamentosa* but that it cannot be demonstrated readily in individual hyphæ.

Translocation was then studied in some Phycomycetes, that is, in *R. stolonifer* and *P. blakesleeanus*. These two fungi were grown in flasks with a layer of radioactive agar at the bottom. Individual sporangiophores or tufts were removed and fixed to a glass slide with collodion and autoradiograms prepared. Figs. 2*a* and *b* show the sporangiophores of *P. blakesleeanus* labelled with cæsium-137 and cobalt-60, respectively.

The sporangiophores as well as the sporangia of both fungi displayed considerable grain density giving rise to intense blackening which formed a true image of the morphology of the fungal structures. However, in the sporangia the blackening was far more intense. From these observations it was inferred that the nuclides were readily transported from a food base, frequently 5–6 cm. away, through the sporangiophores and that they accumulated in the sporangia. It is tentatively suggested that the two nuclides were translocated by means of protoplasmic flow. Many workers have reported on this phenomenon in *Rhizopus* and other Phycomycetes and have observed that the direction of the protoplasmic streaming was towards the sporangia in which the protoplasm became concentrated prior to spore formation. The analogy with the movement of cobalt-60 and cæsium-137 is thus apparent. Furthermore, Grossbard[10] reported that where cobalt-60 labelled hyphal fragments of *Phytophthora cactorum* were ruptured, the tracer could be found in the cell content which had oozed out but not in the empty fragments. The fact that the translocation of cobalt-60 could be demonstrated in individual fungal structure far more readily in the aseptate Phycomycetes than in the septate *Pellicularia*, when using a medium with the same activity, provided further support for the hypothesis of transport by protoplasmic flow. Buller[1] has shown that both *R. stolonifer* and *P. filamentosa* displayed protoplasmic streaming, but he postulated that the type of streaming and the rate differed because of the presence of septa in *Pellicularia*. The flow passed only via a single pore in the septum and thus was slowed down, and this may have affected both the rate and efficiency of translocation. It seems likely that cobalt-60 is held firmly by the protoplasm and moves through the fungus only in chemical combination with the protoplasm (by co-ordination of cobalt with the amino functions of proteins, etc.). This fits in with the results of Abelson and Aldous[14], who, working with cobalt-59, showed in the case of *Escherichia coli* that the nuclide was "very tightly bound, within the experimental error no tracer was lost by either the exchange with magnesium or inactive cobalt". They suggested as one alternative a "non-specific, non-metabolic attachment to the proteins and other groups of the organism". Thus, if cobalt-60 is transported through the mycelium it is assumed that it is carried along by the protoplasm as an integral part of it.

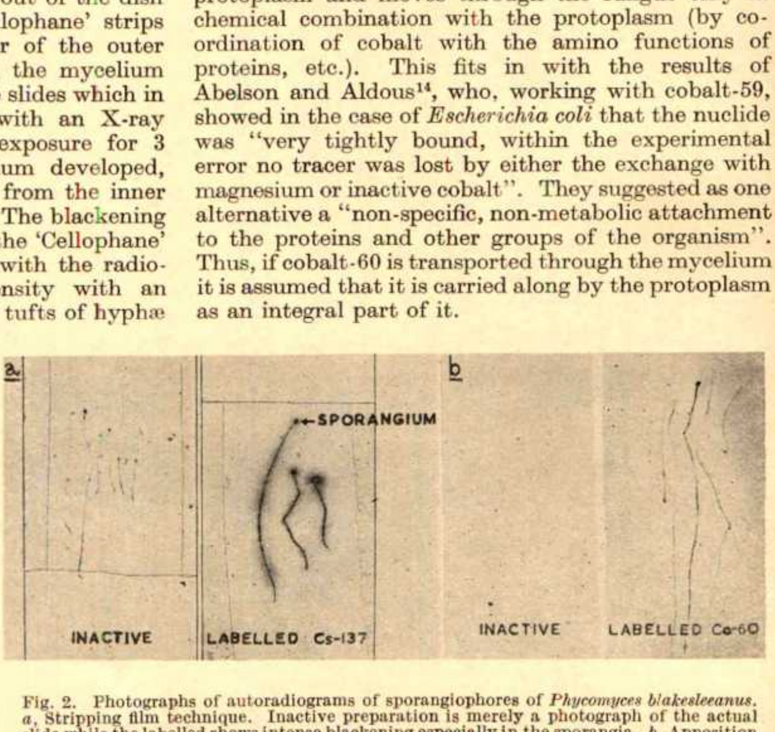

Fig. 2. Photographs of autoradiograms of sporangiophores of *Phycomyces blakesleeanus*. *a*, Stripping film technique. Inactive preparation is merely a photograph of the actual slide while the labelled shows intense blackening especially in the sporangia. *b*, Apposition on X-ray film. Inactive preparation formed no image at all

The above results suggest that all the fungi tested display a translocation mechanism for the two nuclides in agar media, though this is probably more efficient in the case of the Phycomycetes. Failure to detect radioactivity in the new mycelium growing from a labelled inoculum in the soil cannot therefore be explained satisfactorily in terms of an inherent lack of a translocation mechanism in the fungi tested.

While the scanning technique with the scintillation counter could be depended upon to locate a radioactive inoculum in the soil, it may not have been sensitive enough to trace small alterations in the distribution of activity, especially in view of the fact that the strong radiations emitted from the inoculum may obscure any small change in counting-rate due to genuine radioactivity. Having established that both *P. filamentosa* and *R. stolonifer* have the ability to translocate cobalt-60, a more direct method for testing transport via the fungi in the soil was employed. The soil columns after incubation for several weeks were cut into sections of 2 c.c. in the case of *P. filamentosa* and 4 and 6 c.c., respectively, in the case of *R. stolonifer*. Aliquots of 0·5 gm. of soil of each section were extracted with concentrated nitric acid (10 ml.) and the extract counted in a standard *GM*6 liquid Geiger counter tube (Table 2). In addition, a very thin smear was made on a glass slide of 0·5 gm. of very finely ground soil taken from each section, placed on an X-ray film, backed with a 1/16 in. lead sheet and exposed for 3 weeks. Figs. 3*a* and *b* show a representative photograph and corresponding autoradiograms of a preparation and Table 2 summarizes the results.

From both the counts and the autoradiograms, it can be concluded that some slight migration of the nuclide occurred from the soil section containing the inoculum but over a short distance only. This was observed both in the tubes with the killed and living inoculum. Frequently, though not always, movement of cobalt-60 tended to be greater from the killed inoculum. This may be explained in terms of increased permeability of fungal cells after death. As the inocula consisted of disks of agar cultures the nuclide might also have diffused from the agar and not from the fungal structures only. The agar disks were used, because by providing a food base the subsequent growth of the mycelium was greatly enhanced. Other inoculation methods such as by washed mycelium from a broth culture are under investigation in order to eliminate this complication. What migration has taken place may be interpreted on one hand as diffusion of the nuclide from both the agar base and the mycelium and then through the soil, or else as a case of genuine translocation. There is some indication that the migration-rate was somewhat slower in *Pellicularia* than in *Rhizopus*, since in the former activity was rarely found farther than 2 cm. from the inoculum. An analogy with the more efficient translocation mechanism of *Rhizopus* as observed in agar culture suggests itself; but further confirmatory experiments are necessary before drawing final conclusions, for the migration-rate is dependent on many environmental factors, not easily standardized. Whatever the mechanism of the

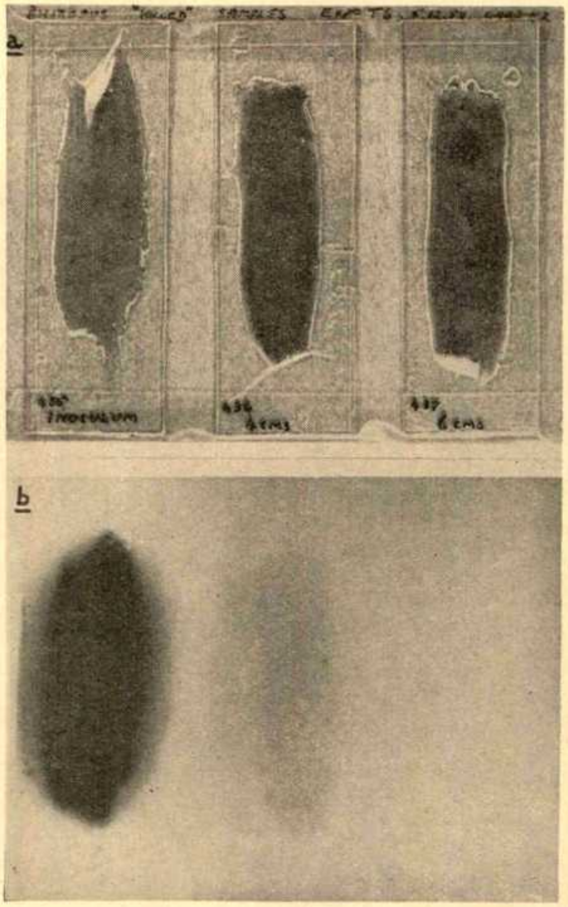

Fig. 3. Photograph (*a*) and autoradiogram (*b*) of soil smears from a soil growth tube of *Rhizopus stolonifer* (killed inoculum, cobalt-60). Soil with inoculum gives the most intense image, a true reproduction of the soil smears. At a distance of 4 cm. the image is much weaker, and at 6 cm. none is formed

Table 2. RELATIVE RADIOACTIVITY OF SOIL SAMPLES FROM GROWTH TUBES OF *Rhizopus stolonifer* AND *Pellicularia filamentosa* (Co–60) BASED ON COUNTS OF SOIL EXTRACTS AND AUTORADIOGRAPHY OF SOIL SMEARS

Exp. No.	Organism	Inoculum	Distance from inoculum (cm.) 0 Act. (per cent)	0 A.R.G.	2 Act. (per cent)	2 A.R.G.	4 Act. (per cent)	4 A.R.G.	6 Act. (per cent)	6 A.R.G.	12 Act. (per cent)	12 A.R.G.
1	*R. stolonifer*	Living	100	++					0·16	0	0·06	0
		Killed	100	++					0·4	0	0·06	0
2*		Living	100	++			1·66	+	0·07	0	0	
		Killed	100	++			6·5	+	0·14	0	0·05	
3		Living†	100		0·75		0·02		0			
		Killed	100		8		2·47		0		0	
1	*P. filamentosa*	Living	100	++	0	0	0	0	0	0	0	
		Killed	100	++	0	0	0	0	0	0	0	
2		Living	100	++	0·33	+	0	0	0	0	0	
		Killed	100	++	0·8	+	0	0	0	0	0	

A.R.G., autoradiograms; Act. (per cent), percentage of radioactivity as compared with that of the inoculum; *, see Figs. 3 (*a*) and (*b*); †, a living inoculum was used but no growth occurred; ++, intense image; +, weak image; 0, no image.

migration of cobalt-60 and whatever the difference in rate between killed versus living inoculum or *P. filamentosa* as compared with *R. stolonifer*, the percentage of cobalt-60 and the distance over which it is transported are very small indeed. In every case most of the activity is retained in the section of the soil containing the inoculum. There the nuclide may be held by either adsorption on the soil colloids after having diffused through the cell wall of the fungi or within the hyphæ of the original inoculum, possibly bound to the protoplasm.

Regarding the first point, this would fit in with the observation of Jones *et al.*[15], who have shown that in a soil with moderate exchange capacity cobalt-60 remains close to the surface even after repeated applications of water. These workers placed the cobalt-60 directly in the soil, while in the experiments described here it was introduced via the fungal inoculum ; the soil used was one of moderate exchange capacity.

On the second possibility, Harley and McCready[5] have shown that in the case of excised mycorrhizal roots of the beech 90 per cent of phosphorus-32 absorbed from aerated media was found to be held in the fungal sheath and only 10 per cent diffused into the core. This ratio varied with environmental conditions[6]. By analogy it could be assumed that cobalt-60 also is firmly held within the fungal tissue, especially in view of the observations that migration is of lower order from the living than from the dead inoculum. Thus, the possibility is not ruled out that the small migration which had occurred from living inocula was due to some extent to active transport inside the fungal tissue, perhaps by protoplasmic flow. This is a hypothesis, and more work is required to distinguish between migration by diffusion or by active translocation. Probably both factors will operate simultaneously.

Our thanks are due to Dr. William Davies for his interest in this work, for encouragement and guidance and for providing facilities to carry out these studies. We are indebted to Mr. G. E. Barton for his valuable collaboration and technical assistance, without which this work would not have been possible, and to Mr. D. Smith for the preparation and counting of soil extracts.

[1] Buller, A. H. R., "Researches on Fungi", 5 (Longmans, Green and Co., London, New York and Toronto, 1933).

[2] Schütte, K. H., *New Phytol.*, **55**, 164 (1956).

[3] Melin, E., and Nilsson, H., *Physiol. Plant.*, **3**. 88 (1950).

[4] Melin, E., and Nilsson, H., *Svensk. Bot. Tidskr.*, **46**, 281 (1952).

[5] Harley, J. L., and McCready, C. C., *New Phytol.*, **51**, 56 (1952).

[6] Harley, J. L., McCready, C. C., and Brierley, J. K., *New Phytol.*, **57**, 353 (1958).

[7] Grossbard, Erna, and Stranks, D. R., Exp. Progr. No. 10, Grassl. Res. Inst., Hurley, 78 (1957).

[8] Grossbard, Erna, and Stranks, D. R., Abstr. Int. Congr. Microbiol., 35 (1958).

[9] Grossbard, Erna, and Stranks, D. R., *J. Gen. Microbiol.*, **20**, 4 (1959).

[10] Grossbard, Erna, *Nature*, **182**, 854 (1958).

[11] Middleton, L. J., *Nature*, **181**, 1300 (1958).

[12] Gustafson, F. G., *Amer. J. Bot.*, **43**, 157 (1956).

[13] Pelc, S. R., *J. App. Rad. Isotopes*, **1**, 172 (1956).

[14] Abelson, P. H., and Aldous, Elaine, *J. Bact.*, **60**, 401 (1950).

[15] Jones, G. B., Riceman, D. S., and McKenzie, J. O., *Aust. J. Agric. Res.*, **8**, 191 (1957).

OBITUARIES

Prof. Kaj U. Linderstrøm-Lang, For.Mem.R.S.

The death of Prof. Kaj Ulrik Linderstrøm-Lang on May 25 was a great and irreplaceable loss, not only to his colleagues and friends but also the scientific community at large. The Chemical Division of the Carlsberg Laboratory in Copenhagen, which he led with such force and inspiration for twenty-one years, is perhaps unsurpassed in terms of the number of individuals who identify it as a major scientific home.

Linderstrøm-Lang was born in Frederiksberg, Copenhagen, in 1896, the son of Dr. C. F. Linderstrøm-Lang. His education at the Danmarke tekniske Højskole led to a degree in chemical engineering in 1919, following which he became assistant to Prof. S. P. L. Sørensen at the Carlsberg Laboratory. In the environment of Sørensen's fundamental research on the physical chemistry of proteins in solution, Linderstrøm-Lang's natural talents for mathematics and laboratory experimentation led him to conceive in 1925 his classical paper "On the Ionisation of Proteins", which stands to-day as the fundamental theoretical treatment of protein titration curves.

During the period 1926–27 he studied in the laboratory of Prof. R. Willstätter in Munich, and there he developed his continuing interest in the chemistry and mode of action of proteolytic enzymes. Upon his return to Copenhagen he completed his earlier investigations on the electrophoretic properties of proteins and presented his doctoral dissertation in 1929.

His investigations of the nature and determination of proteolytic enzymes, developed in collaboration with the increasing flow of visiting scientists in the Laboratory, became directly applicable to the work he afterwards undertook in collaboration with Dr. Heinz Holter, who went to the Laboratory in 1930. Linderstrøm-Lang and Holter developed, over the succeeding ten years, a tremendous array of delicate and sensitive techniques for the study of the distribution of a large variety of enzymes and other constituents in cells. These micro methods, now standard procedure in many laboratories throughout the world, made possible an enormous advance in our understanding of many aspects of cellular physiology. It is characteristic of the methods that Linderstrøm-Lang developed that they were based on extremely simple but basic physical principles. Well-known examples are the Cartesian diver technique for the measurement of metabolism in single micro-sections of tissue or of individual cells, and the extremely sensitive gradient technique for the determination of the densities of minute quantities of material. A whole generation of young chemists and biologists was strongly influenced by these methods and profited enormously by direct collaboration with Linderstrøm-Lang during this period of his scientific career.

When S. P. L. Sørensen retired in 1938, Linderstrøm-Lang was chosen as director of the Carlsberg Laboratory. Continuing along the lines begun by Sørensen, which had already made the Laboratory world-famous in protein chemistry, Linderstrøm-Lang initiated an outstanding series of studies on the internal structure of protein molecules. Using as probes such phenomena as the volume contraction occurring as a result of proteolytic cleavage of peptide bonds, he began to develop during this period his strong interest in the limited modification of proteins as one means of elucidating internal structure, and published many fundamental papers on such systems as the conversion of chymotrypsinogen to chymotrypsin and ovalbumin to plakalbumin. An example of his inexhaustible ingenuity in the development of experimental techniques was the 'deuterium exchange' technique, which permitted the estimation of the relative rates at which individual hydrogen atoms within the primary, secondary and tertiary structures of a protein molecule could reach equilibration with deuterium atoms in the water in which the samples were dissolved.

Linderstrøm-Lang's scientific talents, combined with his characteristics of warmth and perception, brought him early and frequent recognition by many organizations, both scientific and civic. In addition to receiving numerous honorary degrees from universities throughout the world, he was a member of the Royal Swedish Academy of Sciences, the Academy of Sciences of the U.S.S.R., the Royal Society of London, the Finnish Scientific Society and the National Academy of Sciences of the United States, to mention only a few. He was, at various periods during his life, president of the Danish Academy of Technical Sciences, the Akademiet for de tekniske Videnskaber, and in 1958 of the International Union of Biochemistry.

The list of honours and accomplishments scattered through his career are too numerous to list in detail. Perhaps even more important than these tangibles, however, was the impact of his warm personality on everyone who knew him. Kaj Linderstrøm-Lang had talents in many areas of human endeavour and, had he not chosen science as his major interest, could clearly have contributed prolifically in a variety of pursuits including music, art and literature. Those who knew him will not forget his unique combination of wisdom, humour and intellectual integrity. With his death the world lost not only a great scientist but also a great man.

C. B. ANFINSEN, JUN.

Dr. M. Copisarow

MAURICE COPISAROW who died on April 15, in his seventieth year, was a scientist of quite outstanding ability. His university education was acquired between 1909 and 1913 in the School of Chemistry at Owens College, where I knew him as a fellow student. He stayed on for postgraduate study as Dalton Research Scholar during 1914–16, working with Chaim Weizmann on "Phthalides of the Benzene, Naphthalene and Carbazole Series" (published in 1915). Afterwards, as Honorary Research Fellow (1916–19), he launched out into independent inquiries concerned mainly with reactions promoted by aluminium chloride.

During the First World War, Copisarow worked for the Ministry of Munitions and was responsible for a change in the method of washing TNT which greatly reduced the risk in handling this explosive. At the end of the War he experimented on the conversion of various explosives and also phosgene into products for which industrial uses could be found, and in these operations his eyesight suffered severe injury. Most unhappily, the damage was progressive and in a relatively short time, while still at the outset of his career, he became blind. However, by 1925 he had to his credit nineteen publications of high quality, and in that year he was awarded the D.Sc. of the University of Manchester.

In his work as a chemist he could never have confined himself to narrow specialization. His mind ranged over whole fields of scientific activity, and his keenness of perception allied to his uncommonly active imagination gave rise to a versatility which is well exemplified by his generalized theory of allotropy (*J. Chem. Soc.*, 1921) and by his work on the phenomenon of periodic precipitation, reported between 1927 and 1932 in various scientific journals. These publications illustrate admirably his ability to recognize certain apparently unrelated chemical processes and structures as forms of expression of a unifying principle and to enunciate it.

After he had lost his sight, Dr. Copisarow's scientific activities became restricted principally to the preparation of review articles and essays dealing with matters calling for theoretical consideration. His blindness seemed indeed to intensify his insight, and he extended his thinking to such subjects as the functioning of certain oxidation enzymes, the effects of radiation on enzymes and the biochemistry of virus infection. He studied these matters with the ultimate object of selecting and co-ordinating knowledge which might throw light on problems associated with the malignant growth of cells. Observations on biochemical work in the field of cancer research were published over a period of years in several journals, including a comprehensive review on the "History of Human Cancer", which appeared in the *Edinburgh Medical Journal* in 1952. Copisarow's writings on these matters were prompted by his great desire to contribute all he could to the furtherance of progress in the war on disease.

Further evidence of his feeling for the well-being of his fellow-countrymen is afforded by the interest he had in the application of appropriate scientific knowledge to agricultural pursuits, and during the Second World War he was active in advising on methods for grassland improvement and for the reclamation of bracken-covered areas. In all, he published eighty-three scientific papers, and in recognition of special services to his country he was placed on H.M. Civil List.

Dr. Copisarow was a man dedicated to the work he had chosen, and though, in later years, he had to endure much ill-health and many worries, he remained courageous in adversity, sustained to no small degree by religious faith and by the devotion of his wife and family.

T. K. WALKER

Dr. D. S. Gracie

VOLUNTEERING in the Royal Scots at seventeen, David Smart Gracie was badly wounded on July 1, 1916, at the Somme, and spent the rest of the First World War as a prisoner in Ruhleben, an experience which marked him for life.

In the late 'twenties, after graduating at Edinburgh with a medal, and lecturing on agricultural chemistry, he went to the Colonial Service and carried out a notable "Preliminary Survey of the Soils of Kenya" before the Colonial Agricultural Service had been reconstituted.

Moving to the Egyptian Ministry of Agriculture in 1930, Gracie spent two decades investigating the fascinating problems presented by a soil which has sixty centuries of cultivation history, capped by its change to irrigation all the year round during the past hundred years. As the last survivor within that Ministry in 1949 of what had once been a strong team of some twenty British scientific ex-patriate workers, he finished with a chattering Brunsviga by collating and analysing his results from sixteen continuous years of field experiments on the cotton crop. One side-issue during the Second World War from his work on other crops was to economize tonnage of merchant shipping by showing that imported artificial fertilizers produced much more food for the Egyptian than grain imported as such, which the British army had to bring in for its own use.

In 1949 Gracie started afresh in the dusty precincts of Amman with scanty resources, locating cultivable areas in the Jordan valley and the desert for the United Nations Arab Relief. In 1955 he transferred to Iran with better resources, where he created a large efficient laboratory organization for the United Nations Technical Assistance Board at Teheran. In 1958 he broke down from heat exhaustion, and retired to his Edinburgh home too late, dying there on May 31 of this year, leaving his wife Vera and one son.

With all his work done overseas, in countries not notorious for gratitude, merely increasing the resources of those countries by many acres of cultivation or many more tons of annual crop, he is likely to be one of those for whom there is but little remembrance—a depressing reflexion on those fine political projects for under-developed countries.

Gracie has been described as "a fierce seeker for truth, who could never suffer a rogue gladly", though he might tolerate a fool. He held on to his standards of precision, and made sure that his native assistants did the same.

Out of thirty years joint experience, a mutual friend writes of "the qualities of integrity, judgment, and application in good and indifferent health which he brought to his work. He had none of the narrowness with which specialists are sometimes charged; he was widely read in a diversity of subjects and worth listening to on any of them. Unbending in his uprightness with an inner light which lit for him so clearly the path he held in all affairs, yet he was not stiff; human, kindly, generous, and considerate, his friendship was one of the wholly good things a man could be blessed with". W. Lawrence Balls

Dr. W. W. Francis

Dr. William Willoughby Francis, librarian of the Osler Library at McGill University, Montreal, since 1929, died on August 10, aged eighty-one. A relative of Sir William Osler (his mother was Osler's first cousin, and Osler always spoke of him as a nephew), he was born at Montreal on April 2, 1878, and was educated at Trinity College School, Port Hope, and at Johns Hopkins University, Baltimore, where he graduated A.B. in 1898 and M.D. in 1902. After further study in Montreal, Baltimore, Vienna and London, he returned to Montreal in 1906. In 1912 he was appointed assistant editor of the *Canadian Medical Association Journal* and secretary-treasurer of the Canadian Medical Association, and in 1915 he went overseas with No. 3 Canadian General Hospital (McGill) as registrar. On demobilization in 1919, he lived in Oxford (where Osler was regius professor of medicine) before he became editor of the *International Journal of Public Health* at Geneva.

Dr. Francis's *magnum opus* was started in 1922, when he joined R. H. Hill, Archibald Malloch and Leonard Mackall in compiling the catalogue of Osler's magnificent library at Oxford. Working for 14–16 hr a day for seven years, he succeeded nobly in interpreting Osler's dream of an ideal biobibliography of epoch-making books and in staging it as a pageant. The catalogue under the title "Bibliotheca Osleriana" was published by the Oxford University Press in 1929, and the Osler Library at McGill was officially opened on May 29 of that year. Dr. Francis was president of the Medical Library Association during 1935–37, and honorary consultant to what was then called the Armed Forces Medical Library at Washington.

Bearing a striking resemblance to Osler in the shape of his head, his olive complexion, his dark, humorous eyes, the lightness of his step, and several of his mannerisms, 'Bill' or 'Billy' Francis was a charming man. Someone said of him that he was born under a dancing star and sang his way through life. His learning was vast and bizarre, but never pedantic, his memory was rich and retentive, his humour was spicy and puckish. His seemingly infinite leisure was at the disposal of the young and old who went to him for inspiration and for help. A classical scholar, a painstaking bibliographer ("his meticulosity exceeds anything you ever met with"—Osler), and an unsurpassed writer of whimsical letters, Dr. Francis married in 1921 Hilda Colley, who survives him, with his daughter, Dr. Marian Kelen. W. R. Bett

Prof. A. Preece

The William Cochrane chair of metallurgy in the University of Durham at King's College, Newcastle upon Tyne, became vacant last November with the untimely death of Prof. Archibald Preece at the age of fifty-three.

Preece was educated in South Wales and graduated from University College, Swansea, in 1926. He first joined the Pressed Steel Company of Great Britain as metallurgist, and later became a research officer to the South Wales Siemens Steel Research Association, but he returned to academic work in 1933 when he became a lecturer in metallurgy in the University of Leeds. There he pursued researches on the effect of high temperatures upon steel. The importance of his work was recognized by the award of the Sir Robert Hadfield Medal by the Iron and Steel Institute and by his promotion to a readership in the University of Leeds in 1946.

In 1948 he was appointed to succeed C. E. Pearson as professor of metallurgy in King's College, Newcastle upon Tyne. He took charge of a small but active department of teachers and research workers who carried out important work on the scaling of metals, temper brittleness and the solidification of steel castings, which were Preece's particular interests, though he encouraged others to work on a wide variety of different metallurgical topics. Just before his death he had the satisfaction of moving his Department into more commodious quarters and installing new equipment.

Prof. Preece was a deeply religious man who could be stern or kindly as the occasion demanded. He set himself extremely high standards both in his work and in his dealings with students and colleagues. Probably the most outstanding quality by which he will be remembered was his unwavering integrity and his strict adherence to the truth as he saw it. He was deeply devoted to his work and to his Department, and his sudden death was a great loss to all who came in contact with him.

A. F. Burstall

NEWS and VIEWS

Commonwealth Scientific and Industrial Research Organization

Dr. F. W. G. White, C.B.E.

Dr. F. W. G. White, deputy chairman of the Commonwealth Scientific and Industrial Research Organization, Australia, has been appointed chairman in succession to the late Sir Ian Clunies Ross. Dr. White, who is a New Zealander, went to Australia in 1941 at the invitation of the Commonwealth Government to help in Australia's effort to provide radar equipment for the Australian and United States Forces. When the Organization was formed in 1949 he became chief executive officer, and in 1957 deputy chairman. During the period of reconstruction following the War Dr. White played a leading part in building up the laboratories of C.S.I.R.O., which have since then assisted in the growth of Australia's secondary industries. He was largely responsible for the establishment of laboratories for meteorological physics, coal research and building research. He has been active in sponsoring the formation of industrial research associations and in helping firms to create their own research facilities. Dr. White has taken a direct interest in the development and work of the Organization's laboratories concerned with biological research and has travelled widely to study agricultural and pastoral problems at first hand. Since 1946, when special funds were made available for wool research, he has devoted a considerable effort to the founding and development of the C.S.I.R.O. Wool Research Laboratories, which have done much to sustain wool in the competitive fibre markets of the world.

Dr. White graduated as M.Sc. in 1928 in the University of New Zealand and later went to do research work at the Cavendish Laboratory, Cambridge. He was awarded the Ph.D. degree of the University of Cambridge in 1932. After a period as a University teacher in the University of London, he was appointed professor of physics at Canterbury University College in New Zealand.

Dr. R. N. Robertson

Dr. R. N. Robertson, a distinguished Australian plant physiologist, has been appointed a full-time member of the executive of the Commonwealth Scientific and Industrial Research Organization in succession to Dr. F. W. G. White. Dr. Robertson is an outstanding research worker who has unusually wide interests in both basic and applied aspects of plant physiology. Many of the complex problems facing the farmer and the fruit-grower can only be solved if we know how the plant functions—how it absorbs minerals from the soil and how it uses them to build up its structure. Dr. Robertson has been concerned with these basic problems throughout his career and particularly in his present position as leader of the Plant Physiology Research Unit jointly operated by the Division of Food Preservation and Transport of the Commonwealth Scientific and Industrial Research Organization and the University of Sydney. Work by Dr. Robertson and his colleagues on the growth and development of apples has led to an understanding of the reasons for the poor keeping quality of large fruit and fruit from light crops. His investigations on the maturity of peas have been of particular importance to the vegetable canning and freezing industries. During the Second World War, Dr. Robertson gave valuable help to the food control authorities through his investigations on the causes of heating in stored wheat. Dr. Robertson has spent the past year as visiting professor of horticultural science at the University of California and is at present on a short visit to the University of Cambridge.

Dr. Robertson was born in Melbourne in 1913. He graduated in science with first-class honours in botany at the University of Sydney in 1933 and continued postgraduate research at that University as Linnæan Macleay Fellow. He was awarded a research scholarship of the Royal Commission of the Exhibition of 1851 and went to work at the University of Cambridge, receiving the Ph.D. degree for research in plant physiology. In 1945 he joined the staff of the Division of Food Preservation and Transport of the Commonwealth Scientific and Industrial Organization and took charge of work on the storage of fresh fruit and vegetables. When a Plant Physiology Research Unit was formed in 1952 as a co-operative venture between the Division and the Botany School of the University of Sydney, Dr. Robertson became its leader. Dr. Robertson is a Fellow of the Australian Academy of Science and a corresponding member of the American Society of Plant Physiologists. The Royal Society of New South Wales awarded him its Clark Memorial Medal in 1954. For many years Dr. Robertson was secretary to the Australian National Research Council.

Agricultural Chemistry in Aberystwyth

Prof. R. O. Davies

Prof. Davies has retired from the chair of agricultural chemistry, University College of Wales, Aberystwyth. His services to the University College of Wales and to the agricultural industry of the Principality have extended from 1920 when he was appointed lecturer in agricultural chemistry; in 1939, he became head of the Department of Agricultural Chemistry in the College, which then also served as the agricultural advisory centre for the Mid-Wales area. On the establishment of the National Agricultural Advisory Service in 1946, he relinquished his post as advisory chemist and devoted his activities wholly to College work and to his interests in research.

Prof. Davies has been especially concerned with problems of the nutritive values of lowland and upland swards and of milk composition, particularly in relation to their mineral constituents. His early work with A. L. Provan and W. J. Pugh established that an increase in the protein and mineral constituents of milk occurred when cows were changed from winter rations to lowland pasture. Experimental work on upland swards with W. E. J. Milton (of the Welsh Plant Breeding Station) was begun in 1930; it shows that the mineral deficiencies of these swards can be rectified without resort to ploughing and reseeding. Long-term treatments of upland swards have led to the extinction of the native hill herbage and its replacement by species of high productivity and mineral content, which have become established voluntarily in the favourable environment created through the improvement of soil status and the control of the grazing animal. More recent work with D. I. H. Jones has shown that the mineral content is one factor that influences the nutritive value of the organic nutrients in upland swards, and that the digestibility and the utilization of the digested nutrients of unimproved hill herbage can be increased by feeding calcium carbonate with the grass.

Prof. T. W. Goodwin

PROF. R. O. DAVIES has been succeeded by Dr. T. W. Goodwin, who since 1949 has been senior lecturer in biochemistry in the University of Liverpool. Dr. Goodwin's early work on vitamins A and C has led on to a wide interest in the biosynthesis of carotenoids and in comparative biochemistry; in these fields, the range of his own studies and those in co-operation with other workers has formed the basis of notable developments as well as for a wide series of reviews and contributions to reference texts. He has had considerable opportunities of contacts with overseas research in his own particular and cognate fields of plant biochemistry, having held a Rockefeller Foundation travel grant in 1954, when he worked in the University of California with Profs. Fox and Mackinney, visited many other American universities, and later having taken part in symposia and lectured in several of the leading research centres in European countries. At Liverpool he has been concerned in the presentation of fundamental and applied biochemical principles, not only to honours B.Sc. students but also in the schools of medicine, dentistry and veterinary science. Dr. Goodwin's wide experience in teaching and research will enhance the resources of the Rural Science Departments at Aberystwyth, which, with the closely associated Welsh Plant Breeding Station, have long had special interests in problems of crop, grassland and animal production.

British Gelatine and Glue Research Association: Dr. D. A. Sutton

DR. D. A. SUTTON, chief biochemist of the South African Council for Scientific and Industrial Research Pneumoconiosis Research Unit at the South African Institute of Medical Research, Johannesburg, has been appointed director of research of the British Gelatine and Glue Research Association in succession to Mr. A. G. Ward, who is going to the University of Leeds as professor of leather industries (see *Nature*, 182, 1707; 1958). Dr. Sutton graduated with first-class honours in chemistry at the Imperial College of Science and Technology, London, and after holding posts with the British Rubber Producers' Research Association and the Paint Research Station, went to Pretoria in 1949 where, until 1956, he was head of the Division of Organic Chemistry of the Council for Scientific and Industrial Research, in charge of groups working on various aspects of industrial organic chemistry. He has since been in charge of investigations of the collagen in various living constituents, the chemotherapy of silicosis, and carcinogen liver protein bonding.

Uranium as Fuel

GREAT BRITAIN'S nuclear power programme is based on the Calder Hall type of nuclear reactor which 'burns' natural uranium as fuel. Uranium ore is mined in Australia, South Africa, Canada and the United States and processed to an oxide known as 'yellow cake'. Material from the Commonwealth is shipped to Great Britain and processed at the Springfields factory of the U.K. Atomic Energy Authority into uranium metal and then into fuel elements for British reactors. A special feature of the March 1959 issue of *Atomic World* (10, No. 3) is a series of three articles linked by the theme "From Mine to Fuel Element, 1959", in which the procedure from the initial mining of the uranium ore to the final fabricated fuel element is described. In the first article, "Mining and Processing at the Mary Kathleen", the mining and treatment of the ore to the 'yellow cake' at the recently completed £13 million installation at Mary Kathleen in Australia is considered. This is followed by an account of the processing at the Springfields factory where new plant is being commissioned, and the final article in the series, entitled "Fabricating the Fuel Elements", describes how the billets of natural uranium are cast into rods which are then machined, heat treated and canned in 'Magnox' (an alloy of magnesium and aluminium) to give the fuel elements used at Calder Hall and Chapel Cross. The complete series of operations has been summarized in a composite flowsheet drawn by the staff artist of *Atomic World*. The drawing, 11 in. × 22 in., is very suitable for use in science sixth forms in schools and in technical colleges, and copies may be obtained (price 2*s*. 6*d*.) from the publishers.

Time Ball at Greenwich

AFTER an absence of more than a year, the Time Ball has recently been erected on a new mast on the roof of Flamsteed House, the oldest of the Royal Observatory buildings at Greenwich. A time ball was first erected there in 1833 and it was in 1919 that the aluminium sphere now used was fitted. It was taken down for overhaul in 1958 and as the operating machinery is not yet complete it is not intended to resume daily dropping until the summer of 1960, when Flamsteed House will be opened to the public as an annexe of the National Maritime Museum.

The Ageing Worker

IN a report recently published by the Nuffield Foundation ("Age and the Working Lives of Men: an Attempt to Reduce the Statistical Evidence to Its Practical Shape". Studies of Ageing within the Conditions of Modern Industry. Pp. 68. London: Nuffield Foundation, 1959. 3*s*. net) F. Le Gros Clark, who has been responsible for a number of monographs on ageing, has addressed himself to answering, as best as present evidence permits, the question, what happens within the conditions of modern British industry to ageing men when failing powers make them no longer fully employable on their normal work. He is concerned, that is to say, not with the psycho-physiological aspects of ageing and the changes that take place in the ageing organism, but with the sociological aspects—the fate of ageing individuals in the contemporary industrial milieu. Reliable evidence on this topic is remarkably hard to come by, and Mr. Le Gros Clark has made skilful use of the available statistical data to arrive at his tentative conclusions. Total incapacity for work increases steadily from the age of 55 onwards, and by the age of 65 about 10 per cent of all male workers are totally incapacitated. By the age of 70 this percentage has approximately doubled. The real industrial problem, however, concerns men who are still fit for work, but who because of failing powers need different and less exacting work. At the age of

65 the author estimates that some 20 per cent fall into this category, while a smaller but still considerable number need alternative work well before their mid-sixties There are, of course, wide differences between occupations and the report provides some provisional data relating to thirty occupational groups The Report suggests that an important question is whether an increasingly mechanized industry will be able to provide the kind of work needed by ageing workers and by those who do not wish to retire at 65 If not, what other social arrangements will be needed to ensure the well-being of the ageing man ?

Staff for Industry and Commerce

Two important publications dealing with the control and development of staff in industry and commerce have been issued by the Institute of Personnel Management The first, by E M Barling, late director of personnel of the John Lewis Partnership, is concerned with the management of workers whose skills are mainly mental or social rather than manual Much of the practice described by Miss Barling will be of interest to those dealing with similar problems in large industrial and commercial organizations, Government departments, public corporations, hospitals and scientific establishments The subjects covered include training and education, pay and incentives, consultation and communications, and welfare amenities (Pp 46 London Institute of Personnel Management, 1959 4*s* 6*d*) The second, by F I de la P Garforth, of the Department of Work Study and Staff Training, Engineering and Allied Employers' West of England Association, provides a systematic approach to the provision of supervisors and managers The subjects covered in the broadsheet include organization charts, staff reviews and appraisals, forecasts of vacancies, recruiting policy, further education and training for staff, job rotation and exchange, and a section on the initiation and operation of a systematic management development policy (Management Development a Systematic Approach to the Provision of Supervisors and Managers Pp 72 London Institute of Personnel Management, 1959 15*s* 6*d*)

I C.S.U. Review

THE activities of the International Council of Scientific Unions have greatly expanded during recent years Joint Commissions have been appointed covering fields of interest common to two or more of the constituent unions and other committees have been formed to organize specific programmes of research The recent International Geophysical Year was initiated and sponsored by the Council through a special committee appointed to supervise the programme Despite these outstanding achievements, there is still widespread ignorance concerning the organization and activities of the International Council of Scientific Unions The lack of adequate information concerning its affairs has been felt to be detrimental to the continued growth of the Council As a step towards remedying this state of affairs, and with the view of encouraging the flow of information between individual unions, the Executive Board of the Council has approved the establishment of a new quarterly journal to be called the *I C S U Review*, to provide information to members of the Council and to all who are interested in international co-operation in science, about the activities of the Council and of the scientific unions The *I C S U Review* will contain reports of meetings of the Bureau, the Executive Board, and the General Assembly of the I C S U , information about special activities, reports of some of the more important symposia, reviews of certain publications, special articles on various aspects of international co-operation in science, and announcements about forthcoming meetings, symposia or congresses organized by the unions In the first issue (May 1959 Pp i+56 Subscription 16 florins , 30*s* , or 4 50 dollars per volume of four issues Amsterdam Elsevier Publishing Co , 1959), Prof A von Muralt, treasurer of the International Union of Physiological Sciences and former president of the International Council of Scientific Unions, has written an article entitled "What does ICSU stand for ?" There are other articles on international collaboration in science by L V Berkner, on the International Geophysical Year by Prof Sydney Chapman, on the marine sciences by Roger Revelle, and a review of some aspects of the origins of life considered in the light of the Moscow international symposium of August 1957, by N W Pirie With the increasing importance of international co-operation in science in recent years, and the growing status of the International Council of Scientific Unions as an essential part of the organization of scientific activities on a world-wide scale, the *I C S U Review* will undoubtedly fill an important niche in the literature of science, and will find a place on the shelves of all scientific libraries and information services

Russian Journal of Inorganic Chemistry

A TRANSLATION of the Russian *Zhurnal Neorganicheskoi Khimii*, the only Russian journal devoted exclusively to inorganic chemistry, is being published by the Chemical Society under the title *Russian Journal of Inorganic Chemistry* In an introduction to the first number, the President of the Chemical Society states that it marks a further step in a plan to make Russian chemical literature more generally available Many chemists have become aware of their loss in being unable to read in the original the numerous important scientific papers now being published in the U S S R Although increasing attention is being paid to the teaching of Russian, the need for English translations will inevitably persist for a long time The publication has been made possible by the far-sighted support of the Department of Scientific and Industrial Research The Council of the Chemical Society believes that the venture will not only be of direct value to many research workers, but that it will serve to strengthen still further the sense of international partnership in the advancement of chemical science The translation is by experts The distributors are Cleaver-Hume Press, Ltd , 31 Wright's Lane, London, W 8 The ordinary subscription rate is £30 (90 00 dollars in the United States) per annum, to libraries of universities and technical colleges £22 10*s* (67 50 dollars in the United States), in both cases inclusive of postage The first number has 105 pages in the large format of the *Journal of the Chemical Society* and includes thirty-nine papers and eight brief communications, in all cases in full The topics cover a wide range of interests in inorganic chemistry, some of the papers bordering on physical chemistry, and the standard is high As indicating the general interest of the journal, mention may be made of one paper in which α-MnS is shown to be photo-oxidized during the recording of the powder X-ray pattern, and the published data on α-MnS are wrong

Digest of Soviet Technology

A *Digest of Soviet Technology* is being published each month by Engineering Information Services, Ltd (No 1 , April 1959 8 Victoria Road, Kirkham, Preston) The subscription rate is £6 6*s* annually Such a new digest, with an editorial policy of giving "express information on recent technological developments in the Soviet Union and Eastern Europe", should be of great value to all persons concerned with technical progress in industrial and academic research It is claimed that the information supplied is obtained by critical reading of a large number of periodicals and non-periodical literature published in Soviet countries The fields of coverage are essentially mechanical engineering, production processes and methods instruments and automation The material is divided into the following sections Design and Production , Metallurgy, Welding and Foundry Production , Instruments and Automation , General News, including inventions and book reviews In the third number (June), the editors state that in future greater attention will be paid to 'non-periodicals' This follows when one realizes that a considerable proportion of Soviet technical information is given in books before it appears in periodicals Certainly when this policy is brought into force the *Digest* will be able truly to provide "express information"

Journal of Research of the National Bureau of Standards

It is announced in the April issue of the *Journal of Research of the National Bureau of Standards* that the Journal is now to be published in four separate sections Section *A* (Physics and Chemistry), to be issued bi-monthly, will cover a broad range of physical and chemical research, with major emphasis on standards of physical measurement, fundamental constants, and properties of matter Section *B* (Mathematics and Mathematical Physics), to be issued quarterly, will be devoted to pure and applied mathematics, including mathematical statistics, theory of the design of experiments and numerical analysis , theoretical physics, chemistry and engineering, with emphasis on the mathematical content , and logical design, programming, and computers Section *C* (Engineering and Instrumentation), to be issued quarterly, will include new developments in instrumentation. data processing, test methods, and some of the work in acoustics, applied mechanics, building research and cryogenic engineering Section *D* (Radio Propagation), to be issued bi-monthly, will report research in radio propagation, communications, and upper atmospheric physics The separate sections may be subscribed for individually

British Scientific Instrument Research Association Publications

It is announced in a recent issue of the *Bulletin of the British Instrument Research Association* that several changes are to be made in the regular publications of the Association Henceforth, the *Bulletin*, *Sira Technical News* and *Research Reports*, together with other office matter, are to be printed by the Association For this purpose an office type composing machine (supplied by Vari-Typer Ltd , London) and a Rotaprint rotary printing machine have been installed The type faces used for the *Bulletin* and the *News* will differ from those at present, but the 10-point size will be retained The *Bulletin*, which was originally intended to be circulated to members of the Association only and which now is generally available, contains abstracts from current literature relating to the construction and use of scientific instruments, and news of the Association's activities in a section entitled "Association Notes" However, since March 1953, the second monthly publication, *Sira Technical News*, with a circulation limited to members only, has been issued, the specific aim of which is to tell the members about the Association's work "Association Notes" will therefore, in future, be transferred from the *Bulletin* to *Sira Technical News*, and the title of the *Bulletin* is to be changed to *Instrument Abstracts*

Feltmaking Research

The eleventh annual report of the Director of Research of the British Hat and Allied Feltmakers Research Association for the year ended August 1958 (pp 20 Manchester British Hat and Allied Feltmakers Research Association, 1959) refers to the inclusion of research on finishing processes as a full-time activity Work on the carrotting of furs has shown that the quality of the felt produced is related to the method by which it is obtained and further work has established the importance of body size, weight and build, relative to the size and substance of the hat Work is to start on the stoving of skins in the carrotting process and work on wool noils indicates that only 35 per cent of the overall variability of the felt-quality parameters can be explained by chemical tests for damage Further work was carried out on the determination of the solubility in alcohol of grades of lac, and a study of a new multiroller machine for both settling wool and felting fur bodies indicates that multirollers can be made to give a rapid rate of felting without adversely affecting the quality of the felt, by using a balanced combination of pressure, jig amplitude and frequency, together with a predetermined traverse rate and controlled temperature and acidity A detailed study was made of the technology of a fur-hardening machine as it affects the quality of the hardened forms and hat bodies produced, and in further work on the use of polyethanoxy compounds as dyeing assistants a relation was found between dyeing properties and the partitioning of the dyes into a layer of ethanoxy compound above water dyes with the highest partition coefficients gave the best results on dyeing Studies on frictional properties of felt indicate that frictional behaviour against wood depends on the surface roughness, whereas against phenol-formaldehyde resins, the nature and structure of the fillers are important Work was initiated on the measure of hat felts for tensile properties

The Regional Research Laboratory, Hyderabad

The annual report for 1957–58 of the Regional Research Laboratory, Hyderabad (pp ix + 136 Hyderabad, 1958), emphasizes the further reorientation of the research programme both for team-work and the grouping of schemes into projects For the internal planning and conduct of research the operational research approach has been followed, and this is outlined in the report A striking feature of the year was the increase in pilot-plant work, and particular attention is also directed to the work on 'Citicide', a powerful new insecticide from turpentine developed in the Laboratory , on 'Hykole', active carbons produced from coke , the production of phenylacetic acid and phenylacetamide, for use in the production of penicillin , and on 'Loungimin', a flavouring agent which has twenty times the strength of vanillin Besides brief notes on progress in the various research schemes, arranged under some thirty project headings, the report includes notes on X-ray, instrumentation and physico-chemical studies, analytical work, equipment and machinery, as well as a list of publications and patents, colloquia held during the year, and lists of research staff, Executive Council and Scientific Advisory Committee Somewhat fuller details are given of the castor-oil project, which embraces the refining of the oil, the preparation of triricinolein, using hexane as solvent, the hydrogenation of castor-oil and the preparation of surfactants, the cotton-seed project (including refining, storage, pilot-plant processing and hydrogenation to fatty acids), the fatty acids project, the dehydrated castor-oil project, entomological studies on insecticides, the hand-made paper project, the utilization of the products of low-temperature carbonization of coal (including the preparation of pitch and road tar, preparation of creosotes for wood preservation, recovery of motor spirit, recovery and fractionation of tar acids and their chemical examination) and the glass and ceramics development project

Fencing Posts in Australia

MILLIONS of miles of fences divide and subdivide grazing and farm lands in Australia Their construction, replacement, and maintenance form a major cost item for primary producers A survey carried out a few years ago by the Commonwealth Scientific and Industrial Research Organization Division of Forest Products, with the assistance of the State Departments of Agriculture, gathered essential information on materials, methods, costs, fence-life, and causes of failure of fences on hundreds of farms across the country (Rural Research in C S I R O , 27 Melbourne, March 1959) Much of the cost is in the posts, and years earlier the Division had begun testing small, round, wooden posts to see if they would be suitable After some thirty years trial they proved to be efficient if preserved against decay and insect attack by treatment with creosote An alternative method of treatment using water-soluble preservatives has been developed more recently The Postmaster-General's Department has adopted full-length preservative treatment for its telegraph poles and, as a consequence, expects an average saving of £2 million a year over the next forty years This figure shows the savings that could be made if all farmers used round preserved posts for their fencing requirements Those who are already using such posts have considerably altered their outlook on fencing An important step in reducing fencing costs has been made Other aspects, such as design, have been neglected and appear to offer fruitful fields for research

Inflorescence Inception and Leaf Size in Gramineae

M BORRILL, in a study of the successive leaves on the flowering shoots of *Glyceria*, *Lolium* and *Triticum*, has observed that the blades of successive leaves were progressively longer, eventually reaching a maximum, after which the blades of the last few leaves produced before heading were shorter When the longest leaf blade was elongating, dissection of the shoot apices showed that inflorescence initiation was taking place Epidermal cell measurements in *Triticum* indicate that differences in blade length are due to differences in the amount of cell extension It appears that a correlated change occurs in blade morphology associated with the onset of the reproductive state of the shoot apex, brought about through changes in the amount of cell extension A study of the effect of different amounts of low temperature and different day-lengths on the relation between inflorescence inception and the production of the longest leaf blade showed that, under some conditions, this relation can be disturbed (*Annals of Botany*, N S , 23, 217 (1959))

Belgian Oligocene Foraminifera

THE second of a series of studies on the Belgian Palæogene by a team of micropalæontologists at the University of Utrecht consists of a memoir by D A J Batjes on "Foraminifera of the Oligocene of Belgium" (Institut Royal des Sciences Naturelles de Belgique Mémoire No 143 Pp 188+13 plates Bruxelles 1958) Hitherto very little was known about them, although the Belgian Oligocene includes the type areas of the Tongrian and Rupelian divisions The samples investigated were collected both from surface outcrops and from borings and mineshafts, so that essentially the whole Oligocene was covered Further, some German and Dutch Oligocene and Belgian and German Miocene deposits were examined Altogether some 140 species (of which two are new) are described, all, with the exception of *Nummulites germanicus* (Bornemann), belonging to the smaller foraminifera The author considers that some eight may be index-fossils for the Oligocene, or in any event for the Boom Clay and Septaria-clay One, *Cassidulina carapitana* Hedberg, widely distributed in the Tertiary of the Caribbean-Antillean area, is described for the first time from Europe The faunal assemblages have close affinities for much of Oligocene time with those of north-western Europe and not with those of areas farther south Dr Batjes also made detailed observations on the lithology and lateral variation of the deposits in different parts of Belgium Correlating these with the foraminiferal assemblages, he is led to postulate that parts of the Tongrian and Rupelian deposits are of the same age, and that similar relations may exist between the Rupelian and Chattian

A Reinterpretation of Charnockites

SINCE the publication of Sir Thomas Holland's classic memoir on the charnockite series of peninsular India nearly sixty years ago, similar rocks have been discovered and studied in many parts of the world, and various theories of their origin have been put forward without, however, a thorough knowledge of the type area near Madras from which these rocks were first recorded A detailed re-examination of the rocks of this area has been made by A P Subramaniam (*Amer J Sci* , 257, 321, May 1959) Mineralogical, petrographical, and chemical data are presented which indicate that Holland's "Charnockite Series" in fact contains members which are genetically unrelated to one another Charnockite is re-defined as a hypersthene-quartz-felspar rock with or without garnet, characterized by greenish-blue felspars and greyish-blue quartz The term 'charnockitic suite' is suggested for a group of related alaskites, charnockites (birkremite), enderbites, and hypersthene-quartz syenites, all of which are partly garnetiferous This series corresponds to the "Acid" division of Holland's 'Charnockite Series" The "Intermediate" division of Holland consists of an assemblage of hybrid rocks derived by interaction between charnockite magmas and pyroxene granulites of the basement The "Basic" division of Holland consists principally of pyroxene granulites and interstratified quartzo-felspathic garnetiferous sillimanite gneisses (khondalite), while his "Ultrabasic" division is represented by pyroxenitic schlieren neither the "Basic" nor "Ultrabasic" divisions being related to the charnockite suite The charnockite suite of rocks is considered to be of primary igneous origin, and to have been emplaced as thick sheets and lenses in gently folded basement rocks , all the rock units have later suffered intense regional deformation

Automatic Centrifuge

An eight-page folder issued recently by Ivan Sorvall, Inc , Norwalk, Connecticut, illustrates and describes the super-speed Servall *SS*–3 Automatic Centrifuge and the *SS*–4 Enclosed Centrifuge Both instruments are table-top models with a marked versatility in accepting any one of five different rotors covering a wide range of batch capacities, speeds and gravitational forces After the desired operating speed, running time, and rate of deceleration have been pre-set on the *SS*–3's conveniently angled control panel, the circuit is actuated by the push of a button A particular advantage of the automatic controls is the accuracy with which a given operation may be repeated and complete uniformity of result maintained The *SS*–4 is a manually controlled instrument and the complete control panel is removable for remote operation This is convenient when work demands operation in cold rooms or fume hoods Both centrifuges are designed for rapid adaptation to continuous flow operation with the Servall 'Szent-Gyorgyi and Blum' system, which allows the collection of small amounts of precipitate, in tubes, from gallon quantities of samples

University News . Queen's University of Belfast

The following appointments to lectureships are announced Dr C J M Stirling, organic chemistry , Dr J S Pate, botany , Dr B V Jayawant, electrical engineering , N C Mitchel, geography , W D Ryan, light electrical-engineering

Bristol

The appointment has been announced of Dr W M Shepherd, reader in the University, to the chair of theoretical mechanics The following have been appointed to lectureships P W Bothwell, public health , D R Coles, medicine , D G Osmond, anatomy R Park, civil engineering , N G Sanerkin, pathology

London

The following appointments have been made Prof J L D'Silva, professor of physiology at London Hospital Medical College, to the Halliburton chair of physiology tenable at King's College , A H J Rains, senior lecturer in the University of Birmingham, to the chair of surgery tenable at Charing Cross Hospital Medical School The following have been appointed readers Dr G R Hilson, bacteriology, and Dr D Dexter, morbid anatomy, tenable at St George's Hospital Medical School , J F Smith, morbid anatomy, tenable at University College Hospital Medical School , R E M. Thompson, bacteriology, tenable at the Middlesex Hospital Medical School , Dr P J Grant, engineering science, and Dr B W Martin, applied thermodynamics, tenable at the Imperial College of Science and Technology , E M Rawstron, geography, tenable at Queen Mary College The title of reader in the University of London has been conferred on T E Hughes, zoology, in respect of his post at Birkbeck College , Dr J Wynn Reeves, psychology, in respect of her post at Bedford College , Dr J H Trounce, therapeutics, in respect of his post at Guy's Hospital Medical School

University College of North Staffordshire

The U S Rubber Co has founded a second postgraduate research studentship at the College J Penfold (Nottingham) and J Beard (Southampton) have been appointed to these studentships The Phillips Petroleum Co of Bartlesville, Oklahoma, has founded a postgraduate research studentship at the College, to which C J Panton (Southampton) has been appointed All three research students will work with Dr P H Plesch on problems related to cationic polymerization

Announcements

The Institute of Physics is to hold a conference on Some Aspects of Magnetism during September 22–24 at Sheffield Further information may be obtained from the Secretary, Institute of Physics, 47 Belgrave Square, London, S W 1

An informal Discussion on Flow Properties of Blood and Other Biological Systems, sponsored jointly by the British Society of Rheology and the Colloid and Biophysics sub-Committee of the Faraday Society, will be held in the Department of Physiology, Oxford, during September 23–24 Further information may be obtained from Dr A L Copley, Medical Research Laboratories, Charing Cross Hospital, Strand, London, W C 2, or from Dr G Stainsby, British Gelatine and Glue Research Association, 2a Dalmeny Avenue, London, N 7

A symposium on Depression will be held at the University of Cambridge Post-Graduate Medical School during September 22–26 Information may be obtained from the Secretary, Medical School, Tennis Court Road, Cambridge

The 250th anniversary of the successful use of coke in ironmaking is to be celebrated by a meeting at the University of Birmingham and at Coalbrookdale, Shropshire, during September 23–25 Further information can be obtained from the Secretary, Iron and Steel Institute, 4 Grosvenor Gardens, London, S W 1

The Institute of the Rubber Industry is to hold a conference on Industrial Technical Organization at the Palace Hotel, Southport, during October 9–10 Information can be obtained from the Conference Secretary, Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W 8

The Committee on Geodesy and Geophysics of the Academy of Sciences of the U S S R published in 1957 a short report of 75 pages on the recent work done in the Soviet Union in the field of seismology, seismo-geology, seismological survey, physics of the earth, tectonophysics and the age determination of minerals and rocks A list of seismological stations, abstracts of some of the papers and bibliographies of others are given

BRITISH CAST IRON RESEARCH ASSOCIATION

OPEN DAYS

THE British Cast Iron Research Association, Alvechurch, Birmingham, held two open days on May 28 and 29 The first day was arranged for visits by representatives of member firms and the second day for visitors from other research associations, Government laboratories, universities, technical colleges and local schools

The president of the Association, Mr E Player, inaugurated a new experimental cupola installation The cupola is a shaft furnace in which metal, coke and fluxes are charged alternately and air is blown through tuyères up the furnace shaft This furnace is likely to remain the most important melting unit for cast iron in Britain for very many years The reactions occurring are highly complex and the unit is capable of innumerable variations in design This experimental installation is on a full industrial scale, has mechanical charging and an extensive stockyard Use can be made of cold or hot blast, the latter being achieved by means of a separate oil-fired blast heater built with radiation and convection sections It is expected that air blast temperatures of up to 800° C will be achieved in the experimental work This range of blast temperature is far higher than that on which there is any industrial experience at present The furnace will melt up to about six tons an hour and the molten metal produced will be disposed of by means of a pig-casting machine Interchangeable well and melting zone sections have been provided so that the melting-zone profile can be changed and the furnace operated without a refractory lining in the melting zone and with water cooling The equipment is fully instrumented so that materials and thermal balances can be accurately computed.

Dr J G Pearce, formerly director of the Association, opened a new laboratory block to be devoted solely to study of fume and dust in iron foundries and its elimination This laboratory has a large experimental hall covered by a gantry crane, and is equipped for full-scale studies of the various dust extraction and ventilation problems which arise in iron foundries There is also a dust-estimation laboratory with a comprehensive range of instruments for sampling industrial dusts Estimation of the free silica content of collected dusts is carried out by X-ray diffraction Demonstrations were made of various devices developed by the Association for the control of dust produced during the manufacture of iron castings

In the chemical analytical laboratory the most important display dealt with the application of liquid/liquid solvent extraction and the removal of iron by extraction as chloride, and the acetylacetone complex was demonstrated In connexion with slag analysis, the extraction of heavy metals as diethyldithiocarbamate complexes is being applied to the determination of aluminium Another important display in this laboratory dealt with the determination of trace elements For the determination of aluminium in cast iron the element is separated as the cupferron complex after removal of interfering elements by extraction with diethyldithiocarbamate and chloroform The separation of cobalt, copper, lead and bismuth was also illustrated The determinations were completed by cathode ray polarography or spectrophotometry The demonstration of special methods of analysis was augmented by the display of a cathode-ray polarograph modified by the British Cast Iron Research Association to improve its utility and a spectrophotometer modified for single beam recording spectrophotometry in the ultra-violet region and for use as a high-sensitivity recording flame spectrophotometer

The work of the Association not only covers the material cast iron, but also the material used for the moulds into which the molten metal is cast These are usually clay-bonded silica sands, and the production of castings with good surface finish and free from defects involves consideration of their behaviour when rapidly heated by molten metal The simulation of this cannot be achieved in the laboratory by heating moulding-sand test pieces in normal laboratory furnaces since, because of the low thermal conductivity of the materials, any organic or carbonaceous materials are destroyed before the test pieces are uniformly heated These carbonaceous materials contribute in an important manner to the properties of moulding sands and are substantially not destroyed before a casting solidifies in a normal mould To overcome this difficulty a testing machine using dielectric heating has been developed which enables sand test pieces to be rapidly and uniformly heated to any desired temperature Load/deformation curves can be automatically recorded when the test piece has reached the required temperature One such unit has now been thoroughly tested and an attempt is being made to build similar equipment using a higher frequency and greater power input for still more rapid heating rates The technique should be of interest for the testing of other ceramic and refractory materials at high temperatures, particularly where rapid rates of heating are important

Cast iron is a complex alloy capable of developing a wide range of properties, depending upon the matter in which solidification proceeds The properties of grey cast iron are determined by the dispersion of the graphite phase which originates at a eutectic transformation during solidification The displays indicated that the solidification of this eutectic had received detailed study in terms of nucleation and growth It appears that elements which reduce the interfacial energy between graphite and the melt increase the number of nuclei growing at a given degree of undercooling Sulphur and hydrogen appear to reduce the rate of growth of the eutectic cells The technique by which the nucleation of the iron is estimated by means of eutectic cell counting was demonstrated and stereophotomicrographs of the graphite skeleton within each eutectic cell were shown to illustrate the growth mechanism A special cooling-curve furnace used for solidification studies was also displayed This employed a molybdenum heating element and was constructed so that there was always a constant temperature difference between the surroundings and the sample during solidification and recalescence

The application of the results of the fundamental work on nucleation to practical problems was well illustrated, particularly in connexion with the soundness of iron castings Increasing the degree of eutectic nucleation increases the tendency to shrinkage defects, and methods for reducing eutectic nucleation are being tried The laboratory findings have been well confirmed by industrial trials

Fundamental work is also proceeding on the interplay of thermal and nucleation effects in the production of chilled castings, and also on the mechanism of solidification of white cast irons in which the eutectic of austenite and iron carbide can appear in various patterns related to the nucleation of the melt and the amount of undercooling before solidification The detection of eutectic cells in white cast irons has proved difficult and the use of the reflecting polarizing microscope has so far proved to be the most useful tool

The mechanism of the corrosion attack on cast iron in diesel engine waterways has been studied and the special test rig used was demonstrated Evidence at present shows this to be caused by the accumulation of acidic oxidation products of the glycol in the coolant, the chief of which is formic acid The formation of formic acid is probably accelerated by the loss of the copper corrosion inhibitor

The problem of phosphorus in foundry pig iron was illustrated To a large extent British iron ores of low phosphorus content are exhausted. and foundry pig irons produced from home ores generally contain more than 1 per cent phosphorus This element has many harmful effects in cast iron when present in such amounts and the Association has just completed an extensive survey of the possibility of utilizing high phosphorus iron ores for the production of low phosphorus foundry pig iron It has been possible to demonstrate that by top-blowing with oxygen in a rotary Kaldo converter, the phosphorus of phosphoric pig iron can be substantially eliminated and the iron cheaply recarburized

Cast iron in steam engineering applications is generally limited to temperatures not exceeding 450° F The Association has just completed the first part of an investigation showing that this is an unrealistic limitation since almost all cast irons have dimensional stability up to at least 750° F Creep tests are in progress to provide additional evidence

Cast iron is not a truly elastic material When stressed the strain can be shown to involve a recoverable anelastic component and an irrecoverable component By a study of the stress/strain curve the latter has been shown to involve true plastic deformation and also a mechanism by which the graphite voids are increased in size The application of triaxial stress systems by means of mild notches is shown to modify the mechanical properties Typical results obtained in this investigation were demonstrated

For many years the Association has been studying the influence of the gaseous elements in cast iron, and the practical implications of this work were illustrated In particular, the influence of aluminium in cast iron in causing the decomposition of water vapour, leading to the solution of hydrogen, was emphasized with many industrial examples

The Association maintains a Foundry Operations Section to provide the iron-founding industry with an advisory service on productivity and working efficiency Recently, considerable interest has been displayed in a form of time-lapse ciné photography known as 'Memo-motion' and the equipment used and typical results obtained on foundry operations were demonstrated

The exhibition material was designed to demonstrate that the work of the Association involved largely applied research undertaken specifically in support of the iron-founding industry, its materials, processes, working conditions and productivity Many examples were given illustrating how the worker in a more or less fundamental field could receive inspiration and ideas by contact with the day-to-day problems of industry

H Morrogh

ATOMIC MECHANISMS OF FRACTURE

A CONFERENCE on "The Atomic Mechanisms of Fracture" was held at Swampscott, near Boston, Massachusetts, during April 12–14, organized by the National Academy of Sciences—National Research Council More than 400 people attended, including about twenty from overseas, and twenty-five papers were presented

Although the main emphasis was on the properties of metals, there were a number of papers dealing with non-metallic crystals, and non-crystalline solids In the last category interest centred on dynamic effects H Schardin presented some rather precise results on the measurement of crack velocities in glasses of various compositions which showed that, although it is approximately true that the maximum crack velocity is proportional to the speed of longitudinal elastic waves, there are significant discrepancies which appear to be correlated with the chemical constitution of the material H Kolsky discussed the similarities in behaviour of plastics and viscous liquids when subjected to tensile-stress pulses of short duration, caused by the stress waves from an explosion At the other extreme end of the time-scale, R J. Charles discussed the dependence upon time of the strength of silicate glasses under static loading Attributing this to the chemical action of atmospheric water vapour at the tip of a crack, he adduced supporting evidence from the behaviour of crystalline oxides under similar conditions

In the main field of interest of the conference, it was clear that the complexity of the process of fracture is now agreed Four types can usefully be distinguished (1) ductile, (2) brittle, (3) creep, (4) fatigue It should, however, be emphasized that this is no more than a classification of convenience, each heading probably covers a variety of processes, and when any particular body changes from one piece into two pieces a selection of these processes may have been involved, according to the conditions of the experiment An extreme case arises when a crystal of a soft metal draws down, in tension, to a chisel edge or a point The mechanism, doubtfully included under the general heading of fracture, is the flowing of material away from the developing neck, by single or multiple glide processes It was suggested that the central, fibrous part of the typical cup-and-cone tensile fracture of, say, a copper bar might be essentially similar to this A paper by C Crussard *et al* emphasized the value of the electron microscope in the study of such fracture surfaces—a value which arises not so much from its high resolving power as from its great depth of focus Crussard showed that in such a fibrous ductile fracture there is evidence of repeated nucleation of new cracks ahead of the growing tip of the major crack, such nucleation taking place usually at minute inclusions in the metal The new cracks may then join with the major crack by a process of repeated necking down, as just suggested

R W K Honeycombe and C J Beevers showed that, by suitable choice of conditions, such necking can be suppressed, even in single crystals of a face-centred cubic material, and that when this is done one obtains a mode of separation which can be more properly called a true ductile fracture, the separation of the two parts taking place along a previously heavily deformed glide plane and being apparently controlled by the resolved shear stress on this plane On the other hand, single crystals of iron, tested at low temperatures by N P Allen and B Edmondson, either neck down to 100 per cent reduction of area, as already described, or else cleave along the {100} cleavage plane without obvious prior slip The choice between the two modes of behaviour is determined by the direction of the tensile stress relative to the crystal axes, and the transition is quite sharp

The topic which received the greatest amount of attention during the conference was the well-known ductile – brittle transition in polycrystalline iron which normally takes place rather below room temperature A paper by G T Hahn, B L Averbach, M Cohen and W S Owen reported an extensive series of observations on the tensile fracture of mild steels, of various compositions and grain sizes, over the temperature range 20–290° K , which showed that the phenomena are more complex than had perhaps previously been realized In particular, the authors claim that different processes are important in different ranges of temperature—other things being equal—and that mechanical twinning plays a decisive part at the lowest temperatures

Microscopic observations of specimens broken, or almost broken, under conditions near those obtaining at the brittle – ductile transition showed the existence of numerous micro-cracks, each usually confined to a single grain The frequency of occurrence of such cracks varied systematically with the conditions of the test and the authors maintain that it is necessary to subdivide the process of fracture in this transition range into (*a*) true initiation in which some plastic deformation is probably essential, (*b*) growth within the original grain, (*c*) propagation through the rest of the specimen A useful concept which arises is that the 'effective' value of the surface energy of the newly formed surfaces may be much larger—the authors deduce 10 times larger—for (*c*) than for (*b*) This is indeed reasonable in the light of some of the fractographic studies of J R Low, which show very clearly the change of character of a cleavage surface which can take place when the crack passes from one grain into another less favourably oriented for cleavage

A contribution from N J Petch summarized his own extensive work, relevant to the more metallurgical aspects of the same problem In addition to the grain size, temperature, and strain-rate, which are commonly recognized as important variables, he discussed also the mechanisms by which the carbon, nitrogen and other elements commonly present in steels affect the various stages of the fracture process, and the ways in which their influence can be modified by previous mechanical and thermal treatment The introductory paper by A H Cottrell also dealt with the brittle – ductile transition at some length, in addition to giving a general survey of the whole subject of the conference Although some points of controversy remain, and although much detailed work remains to be done, it appears that the broad outlines of the explanation of the ductile – brittle transition are becoming settled

The two main contributions on creep fracture, namely, on slow fracture at temperatures which are high relative to the melting point, came from N J Grant and R C Gifkins The features which distinguish this type of failure from the others are the considerable importance of grain-boundary sliding and grain-boundary migration, the comparative ease of dislocation climb processes, and the possibility of deformation by the migration of point defects under the action of stress It was made very clear that these four processes can be inter-related in several ways, and that they can all be inter-related to any deformation by dislocation glide which may be taking place in the body of the grains Failure is often, but not always, intergranular, and is often, but not always, associated with the presence of 'voids' in the grain boundaries The fracture behaviour was reported to be particularly sensitive to the presence of small amounts of impurity in a nominally pure metal The paper by Gifkins summarized some of the earlier experimental work, which is considerable in quantity and not always self-consistent It is clear that it is likely to be some time before the present confusion approaches anything approximating to a unified body of knowledge, although the general lines of the pattern are beginning to emerge

The problem of fracture during fatigue is perhaps in the least satisfactory state of all Of the papers presented at the conference, most were concerned with the early stages of the process W A Wood described the interesting results obtained by a taper sectioning method applied to a partially fatigued copper specimen As with so many other papers on other topics, the impression given by this work is that the mechanism of fracture is more complex than had hitherto been supposed The emphasis is on the events taking place close to the surface of the solid, and leading up to the formation of a true crack E S Machlin and A J McEvily described experiments on four inorganic crystals which seem to show an inter-relation between liability to fatigue fracture and the ability of the crystal to become deformed by cross-slip , the possibility of the formation of 'extrusions' from the metal surface also seems to be correlated with both these features A similar point emerges from a comparison of two papers on copper by W A Backofen and N Thompson, respectively, one of which dealt with the effect of crystal orientation on liability to fracture while the other related crystal orientation to extrusions

Mention must also be made of the contribution by E R Parker on the cleavage fracture in tension of single crystals of magnesium oxide These observations, and similar work by Stokes *et al* , mentioned in the course of discussion, demonstrate the advantages to be gained by experimenting on ionic rather than metallic crystals, and emphasize a point that was made on a number of occasions This is that, on close examination, no crystal breaks in a truly brittle manner , the fracture is always preceded by some small amount of plastic deformation This is one of the key points in connecting theories of fracture with current views on the mechanical behaviour of crystalline solids The other general feature of the proceedings, already mentioned, was the evident fact that in no circumstances is fracture a simple process The realization that "when a problem is difficult, it is probably two problems" is perhaps the most important step on the road to a solution

N Thompson

OXIDATION OF ORGANIC COMPOUNDS

A SYMPOSIUM on the oxidation of organic compounds was held in the Stern Hall at Queen Mary College, University of London, during April 13–14

In his opening address Mr D A C Dewdney, director of Esso Petroleum Co , Ltd , spoke of the importance of a free exchange of scientific information and the need of still further fundamental research into basic problems , an improving standard of living and higher productivity are largely dependent on the commercial application of original scientific discoveries In welcoming visitors to the symposium, he referred especially to those from the U S S R and Czechoslovakia

The first part of the scientific discussion was concerned with the course of the oxidation of saturated hydrocarbons by chromic acid in acetic acid containing some sulphuric acid From the papers and the discussion which developed there was general agreement that the first recognizable stage in the oxidation is hydrogen abstraction from the hydrocarbon, and that the factors which influence the speed of the reaction are mainly steric and configurational The same factors also determine the rate of oxidation by chromium trioxide in anhydrous media

Dr J Roček (Institute of Chemistry, Czechoslovak Academy of Science, Prague) reported that *n*-paraffins are oxidized at a rate directly proportional to the number of methylene groups, the rate constant for any individual member being $k_n = k_{CH_2}(n - 2)$, where n is the number of carbon atoms and k_{CH_2} the rate constant for the oxidation of a single methylene group The relative rates of oxidation of the methyl, methylene, and methine groups in open chain hydrocarbons have been found to be 0 015 · 1 · 32–77 Measurements of the rate of oxidation of *cyclo*alkanes disclosed some interesting anomalies

The oxidation-rate of the tertiary CH-group is found to vary somewhat with the bulk and structure of the neighbouring alkyl groups , these variations are due mainly to polar factors and are similar to changes in rates of solvolysis of the corresponding tertiary chlorides Only in special cases has steric retardation been found , steric acceleration does not play any detectable part in the acyclic series It is concluded that the rate-determining step is the formation of a carbonium ion by way of a hydride ion transfer from the hydrocarbon molecule to an oxygen atom of the oxidizing agent

Prof K B Wiberg (University of Washington) from a study of the rate of oxidation of diphenylmethane and of its nuclear substituted derivatives in 95 per cent acetic acid concluded that the oxidation proceeds by initial removal of a hydrogen atom to give a benzhydryl radical which is then oxidized directly to benzophenone In support of such a mechanism, oxidation of optically active 3-methylhexane gives an optically active tertiary alcohol, a result which seems to exclude the initial formation of a carbonium ion The formation of camphenilanic acid by the oxidation of *iso*camphane is also cited in support of that view. Further evidence of an indirect nature is derived from a study of the action of chromyl chloride on propylbenzene-$\beta\beta d_2$, benzyl methyl ketone is among the products, and it was found to have one deuterium atom in the α-position, indicating a deuterium shift during the reaction

The oxidation of tertiary paraffins by chromic acid in presence of sulphuric acid is known to lead to tertiary alcohols, and the course of the reaction can be interpreted in terms of dehydration of the alcohol to olefin In a study of the oxidation by Dr W J Hickinbottom (Queen Mary College, London) the conditions were selected so that tertiary alcohols could not be formed, by using chromium trioxide in acetic anhydride Under these conditions, paraffins gave products which were qualitatively identical with those from the corresponding olefins in presence of weak acids Further, some of the paraffins gave unsaturated products From these results and from quantitative measurements of the rates of oxidation it was concluded that tertiary paraffins are attacked preferentially at the tertiary carbon atom with the subsequent formation of an olefin

A possible key to the oxidation of paraffins by chromic acid may lie in the behaviour of the alcohols which may be derived from them by oxidation Our knowledge of the course of the oxidation of alcohols is based on the work of Prof F H Westheimer (Harvard University) In continuation of this work, he described, with Y E Chang, a study of the oxidation of pinacol and its monomethyl ether. A feature of the pinacol oxidation is that it proceeds 2 7 times as fast in deuterium oxide as in water This was interpreted to mean that the hydroxyl bond is not cleaved in the rate-controlling step of the oxidation The relative merits of an ester mechanism and hydride abstraction were discussed and many useful ideas exchanged

Dr W A Waters (Oxford) reviewed the relationship between vanadate and permanganate oxidations The role of trivalent manganese and of organic free-radical intermediates in permanganate oxidations was reviewed Features diagnostic of one-electron oxidations were brought to notice It was stressed that lack of diagnostic evidence need afford no grounds for the rejection of a reaction mechanism

Dr J W Ladbury (I C I , Ltd , Plastics Division, Welwyn Garden City) and Dr C F Cullis (Imperial College of Science and Technology, London) discussed the oxidation of inorganic and organic compounds by permanganate The development of reaction-rate with time depends on the nature of the compound undergoing oxidation The observed types of behaviour fall, broadly speaking, into four categories according to the shape of the reaction – time curves Thus there may be (1) a continuous decrease in rate with time, usually not strictly according to a second-order kinetic law; (2) an initial autocatalytic development of reaction-rate followed eventually by a decrease due to consumption of reactants; (3) an initial high rate of reaction which rapidly decreases almost to zero and is then followed by an autocatalytic reaction of type (2); (4) an initial high rate followed by a linear reaction – time curve. These various kinds of behaviour were discussed and reasons proposed for the characteristic differences observed according to the nature of the substrates. In the discussion on this, Prof. N. M. Emanuel (Moscow) directed attention to the resemblance between type (3) and the oxidation behaviour he had observed using oxygen.

Dr. S. Littler and Dr. W. A. Waters (Oxford) reported that pentavalent vanadium becomes an oxidizer in acid solution, the active agents being cations, for example, VO_2^+, $V(OH)_3^{2+}$, depending on the acidity, which reduce only to the oxidation-level of quadrivalent vanadium with organic compounds. Kinetic studies were reported of some glycol fissions and of the oxidation of *cyclo*hexanol. In the latter case an initial rapid esterification seems to be involved though the rate-determining stage involves C—H bond fission. Isotope effects in *cyclo*hexanol depending on the oxidizing ion were discussed and a cyclic mechanism proposed.

The oxidation of saturated hydrocarbons in the liquid phase by air is now a matter of both industrial and theoretical importance. Prof. A. N. Bashkirov (Moscow) described his work on the oxidation of the higher paraffins. In this he described a very important development, namely, that the oxidation can be arrested at a predetermined stage. By using boric acid and selecting suitable conditions—a temperature of 165–170° C. and a nitrogen–oxygen mixture containing 3–4·5 per cent of oxygen—the higher paraffins can be converted into the corresponding alcohols in 70 per cent yield. There is practically no degradation of the hydrocarbon molecule and all the possible secondary alcohols are formed.

Prof. N. M. Emanuel (Moscow) discussed a number of interesting aspects of slow branched-chain oxidation reactions of hydrocarbons, and reference was particularly made to the capacity for auto-acceleration and self-propagation and the control of these reactions by homogeneous catalysts. Some of the ideas developed in this paper were shown to have application in biological processes such as retardation and suppression of the growth of malignant tumours in animals.

Prof. H. B. Henbest (Queen's University, Belfast) reported that trialkylamines are readily oxidized by a large variety of reagents, the initial products being usually N-oxides, enamines, or carbinolamines. Depending on its structure and the reaction conditions, a compound of the last type may be oxidized further to an amide or may cleave to a mixture of a secondary amine and a carbonyl compound. Analogous compounds may be formed in the oxidation of dialkyl anilines, but in this series additional products are possible if nuclear positions become involved in the reaction.

A general survey of the field was presented, followed by a more detailed discussion of some of the reactions of trialkylamines and dialkylanilines with N-bromosuccinimide, ceric salts, *p*-quinones, di-tert-butyl peroxide, and benzoyl peroxide. The results with dialkylanilines suggest that the three primary oxidation processes of electron removal, hydrogen atom removal, and hydride ion removal, can all occur, the choice for any particular amine being mainly dependent on the type of oxidizing agent used.

Some known features of oxidations by persulphates were summarized by Dr. R. G. R. Bacon (Queen's University, Belfast) and new data presented. Persulphates may be employed (*a*) as aqueous solutions, undergoing thermal or photo-induced decomposition; (*b*) in strongly acidic solutions; (*c*) in alkaline solutions; (*d*) in redox systems, where persulphate acts in conjunction with, for example, an oxidizable metal ion. The use of persulphate in redox systems was discussed with emphasis on the value of silver ion as the redox partner. Applications of this method to oxidations of alkylbenzenes, phenols, alcohols, carboxylic acids, and amines, were described.

In summing up the proceedings of the symposium, it can be said that its success as a scientific meeting depended very largely on the free and uninhibited exchange of ideas and the discussion of current and unpublished work now in progress.

W. J. Hickinbottom
R. F. Garwood

GAS CHROMATOGRAPHY

The Gas Chromatography Discussion Group associated with the Hydrocarbon Research Group of the Institute of Petroleum has now completed its reorganization following an inaugural general meeting last autumn, held at University College, London, on September 23, 1958, and the first annual general meeting at the Imperial College of Science and Technology, London, on April 10, 1959. Both meetings were held in conjunction with an informal symposium and were attended by more than two hundred participants.

The success of the new organization may be judged from the total enrolled membership, which is now about 220, of which some fifty are from the Continent or the United States. The Group has now organized four one-day informal symposia in Britain and the second formal symposium in Amsterdam in the spring of 1958, which was attended by nearly five hundred participants from twenty-one different countries. In addition, it has published two papers and arranged for the manufacture and sale in the United Kingdom of specially prepared stationary phases and supports in an endeavour to standardize experimental procedures for determining, and methods of presenting, gas chromatographic data. Arrangements are being completed for the collection and distribution of the latter to members, together with abstracts of papers on the technique from more than sixty journals. The future programme tentatively includes another informal symposium to be held at Bristol in the autumn of 1959, and the third formal symposium in Edinburgh during 1960. The outstanding contributions of Dr. A. J. P. Martin, both in originating gas–liquid chromatography and in many important later developments, have been recognized by the Group by bestowing on him honorary life membership.

The technical part of the meeting at University College, London, on September 23, 1958, was introduced by Prof E D Hughes, who gave a short welcoming address commenting on the rapid growth of the Group Dr D Ambrose, the local organizer, then presented proposals on behalf of the Group for the determination of retention volumes under standard conditions Various practical points about the experimental procedures were discussed, including temperature control and the life of columns

Dr G A P Tuey described the work done in his laboratories in preparation for the sale of standardized materials for use as stationary phases Extensive tests had been made of volatility in an apparatus which simulates conditions in the chromatographic column but allows a gravimetric determination of the loss at a particular temperature The rate of loss with time was determined and a final specification includes a figure for initial loss, the steady rate of loss and relative and specific retention data

The comparison of detectors for gas chromatography was the subject of a paper presented by Dr I G McWilliam Detectors were discussed in terms of sensitivity, response time, relationship of detector output to molecular parameters and ease of construction and operation The sensitivity is best stated in terms of gas concentration, and the unit gm /ml of carrier gas was advocated. Base-line noise (μV) and drift (μV /hr) should also be stated The response time must be small enough for negligible distortion of the true peak shape to occur If the relationship between detector output and some molecular parameter is known, quantitative analysis without calibration is facilitated Although all these factors must be considered in selecting a detector, the final choice frequently depends upon the ease of construction and operation Of those in use, Dr McWilliam considers the single-jet flame ionization detector the simplest

Dr K R Garrett presented a report on a programme of co-operative analysis of hydrocarbon gases organized by the Institute of Petroleum Cylinders containing sales butane and a cracked C_4-mixture have been circulated among participating laboratories, where they have been analysed using a range of techniques Preliminary results indicate the importance of standardization of methods of taking samples from the cylinders and enable some assessment to be made of the reproducibility of possible standard procedures

An interesting study of alumina as a packing was described by Mr C G Scott Several methods of achieving different levels of adsorption activity had been tried, but the most promising seemed to be the addition of small quantities of water and silicone oil With optimum proportions it was possible to maintain the ability of the adsorbent to separate hydrogen and methane but with much reduced retention volumes for the higher hydrocarbons An analysis of a gas mixture containing hydrogen, C_1-, C_2-, C_3-, C_4- and C_5-hydrocarbons was therefore possible in a single run at constant temperature

Prof R M Barrer welcomed the Group to the Imperial College of Science and Technology, London, on April 10, 1959, congratulating it on the excellence of the meetings it organized and the vigour and enterprise shown by such a comparatively new organization The local organization of this meeting was carried out by Dr G J Minkoff The first paper, presented by Dr A Goldup, was concerned with the potentialities of the new coated capillary columns in the petroleum industry He described a compact practical apparatus with which capillary columns had been operated at temperatures up to 250° C Column efficiencies in excess of 100,000 theoretical plates had been obtained with metal tubes ten-thousandths of an inch in diameter and 250 ft long coated with squalane or 'Apiezon' grease A novel sample introduction device was described in which the very small samples required for the column were obtained by a dynamic division of the carrier gas at the column head The use of these high-efficiency columns in the analysis of various petroleum products and in geochemical prospecting was illustrated Mr B H F Whyman, another of the authors of this paper, in a prepared contribution to the discussion, described a simple apparatus for drawing long lengths of coiled glass capillary, which show certain advantages over metal capillary

Mr R P W Scott then described the use of fine nylon tubes (0 01 in , 0 02 in and 0 1 in in diameter) as capillary columns Simple coating procedures were used, the transparency of the nylon being helpful in adjusting the rate of flow of the solution of the stationary phase through the tube A column 1,000 ft in length of 0 02 in diameter coated with dinonyl phthalate gave a maximum of 750,000 plates, but the efficiency tended to fall off rapidly with increasing retention time to about 250,000 plates Operating temperatures were limited to about 100° C with present tubing, but 180° C seemed feasible with other polymers A very active discussion took place following these two papers and it is obvious that there is much interest in these new capillary columns, which M J E Golay described for the first time in the autumn of 1957

A new detector employing changes of dielectric constant developed primarily for preparative-scale gas chromatography was described by Mr D W Turner For this application, where high sensitivity is not so important as for analytical work, the detector has the advantages of being largely independent of flow-rate, non-destructive and reasonably robust It employs a novel circuit which is very sensitive to the minute capacity changes produced in the detector cell, and with slight modifications is easily used with solutions such as are encountered in liquid chromatography

Mr V Willis presented a paper on the application of gas chromatography to process stream monitoring, where an instrument is required automatically to sample and analyse a gas or liquid stream over long periods A column-life of two years is aimed at, but is difficult to attain with many stationary phases Although a useful survey of requirements was given, unfortunately few constructional details were available

Finally, in the last paper Dr S H Langer discussed his work on improvement in stationary phase selectivity He exemplified this with his results using tetrahalophthalate esters for the separation of the aromatic hydrocarbons These esters had been selected in an endeavour to exploit the complex formation known to exist between tetrachlorphthalic anhydride and condensed aromatic hydrocarbons Effective separations of the lower aromatic hydrocarbons had been obtained and separation factors and activity coefficients were compared with other stationary phases It seems likely that the electron-deficient tetrahalo-substituted ring interacts with the aromatic compounds by a charge-transfer mechanism

D H Desty

RADIATION SAFETY AND HEALTH PHYSICS

By J W. LUCAS

THE Windscale reactor incident of October 1957 involving the release of radioactive fission products into the atmosphere[1], undoubtedly served to focus the attention of the general public on to the hazards of ionizing radiation and to the increasing risks of exposure Interest has also been aroused by the publication of reports by the Ministry of Health, Medical Research Council[2] and the U N Scientific Committee[3] The rapid expansion of the nuclear power programme, coupled with the increasing employment of sources of ionizing radiation in industry, medicine and research institutions, and also nuclear weapon testing, demands an increasing vigilance and knowledge of the risks and safety precautions on the part of many people The U K Atomic Energy Authority has an excellent record of safety both with respect to its own staff and to the general public in the vicinity of its establishments, and has also exercised a rigorous control over the discharge of waste radioactive products into the environment[4] The Fleck Committee set up to inquire into the organization for control of health and safety[5] nevertheless recognized the need for a rapid expansion of health physics and safety staffs in the Authority, and recommended that the Research Establishment at Harwell should set up a national training centre for health physics and nuclear safety staff to cater for persons both inside and outside the Authority

A number of short courses on "Radiological Protection" have already been held at the Isotope School, Harwell, but it was felt that there was scope for a college of technology to undertake similar work An approach was therefore made to the United Kingdom Atomic Energy Authority, Industrial Group, at Risley, in the spring of 1958 with the view of introducing courses in the Liverpool College of Technology later in the year A scheme was prepared in conjunction with the Authority and this article provides a brief interim report, based on experience of three courses which have been run in late 1958 and early 1959

Each course is of a fortnight's duration The available places on the three courses have been taken up by representatives of the U K Atomic Energy Authority, public health departments, factory inspectorate, local industry, insurance, and education, members attending include medical officers, physicists, engineers, insurance accident surveyors, chemists, public health inspectors and safety officers

The aim of the courses has been to provide an introduction to, and a general survey of, the problems of radiological protection against all forms of ionizing radiation The very specialized problems of reactor safety and the processing of nuclear fuel elements have not been dealt with specifically, except in so far as environmental effects may be involved Special attention in both lectures and practical work is, however, given to subjects such as the comparative properties of radiations, the sources of radiation including background and fall-out, the effects of radiation on plants, animals and man, contamination and decontamination, waste disposal, health physics instrumentation and monitoring procedures, absorption of radiation and shielding. Table 1 summarizes the lecture and practical topics which have been covered on the early courses, the programme is rounded off by visits to local institutions and works, by the exhibition of films, and by discussions

The programme of practical work has been devised to provide a series of short-term experiments, underlining the basic problems of a comprehensive protection service Some aspects of the practical work and the results which have been obtained have already proved of considerable interest and are briefly described It is hoped to publish the detailed observations at a later date

The experiments in radiobiology have been singularly successful in demonstrating the fate of various radioisotopes when brought into contact with biological organisms to be found in a natural environment The techniques have been previously described by D C Pickering and myself[6] The experiments with blanket weed (*Microspora*) have demonstrated conclusively the ability of the algae to concentrate many isotopes from their environment, and have particularly served to emphasize the importance of properly planned disposal procedures A safe procedure for radioactive liquid waste is afterwards demonstrated to members of the course

Table 1 SYLLABUS OF LECTURES AND PRACTICAL WORK

Lectures			Practical	
Section	Topics	No of hours	Subject	No of hours
Radiation and its sources	Comparative properties, units and calculations of dosages, background and fall-out, nuclear reactors, particle accelerators	6	X-ray equipment and sealed sources Techniques with open isotopes—counting and identification	1 7
Measurement and detection of radiation	Principles of measurement, types of counter and H P instruments	5	Calibration and operation of H P instruments Dosage calculations	3
Interaction of radiation and matter	Radiation chemistry, radio-biology-genetics, metabolic processes	6	Radiobiology	7
Radiological protection	M P L's and M P C's, control of internal and external radiation in laboratories and plants, medical care, waste disposal, legal requirements, industrial practice, X-ray units	10	Contamination—prevention and removal Waste disposal Shielding Radiation monitoring Air sampling	4 1 2 2 2

Lectures have been presented by members of the Health and Safety Branch of the U K Atomic Energy Authority Industrial Group, Factory Inspectorate and the Universities of Leeds and Liverpool, in addition to College staff

The importance of thorough testing of materials of construction for contamination properties is not generally appreciated A fairly extensive investigation was undertaken by P C Thompkins *et al* in the United States[7], but data concerning materials available in Great Britain are not readily available A simple test procedure has been devised to provide a measure of contamination for a range of materials and isotopes The method also enables a variety of surface protecting agents and decontamination procedures to be investigated Results on a wide range of materials are gradually being accumulated to provide some form of quantitative assessment of comparative degrees of contamination

The first three courses have provided invaluable experience and have suggested numerous lines of future developments In particular, more advanced courses of three to six months duration are under active consideration in addition to an expansion of work on a number of research projects, leading to the new M C T award

I wish to acknowledge my indebtedness to the U K Atomic Energy Authority for advice in the preliminary stages and assistance with lectures and equipment, to Prof F W Spiers for advice and lectures in the early stages, to Prof A B Semple (Medical Office of Health, Liverpool) for advice and lectures, to Dr Sing for his constant and active support and encouragement, and to Mr D C Pickering for his indefatigable contributions in radiobiology

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[1] (*a*) Stewart, N G , and Crookes, R N , *Nature*, **182**, 627 (1958) (*b*) Chamberlain and Dunster, *ibid* , **182**, 629 (1958) (*c*) Maycock and Vennart, *ibid* , **182**, 1945 (1958) (*d*) Bush and Spiers, *ibid* , **183**, 515 (1959)

[2] "The Hazards to Man of Nuclear and Allied Radiations" Medical Research Council (H M S O , Cmnd 9780, 1956)

[3] Report of the U N Scientific Committee on the Effects of Atomic Radiation , U N General Assembly , Official Records, New York, 13th Session Supp 17 (*A*/3838) (1958)

[4] Dunster and Farmer, *IGS/R/R3* (January 1958)

[5] "The Organization for Control of Health and Safety in the U K A E A " (Cmnd 342) (H M S O , 1958)

[6] Lucas, J W , and Pickering, D C , *Nature*, **182**, 1242 (1958)

[7] Thompkins, P C , *et al* , *Indust Eng Chem* , **42** (8), 1469 (1950)

BRITISH UNIVERSITIES FILM COUNCIL

THE twelfth annual general meeting of the British Universities Film Council took place in Cardiff during May 8–10 This short survey describes its development and traces the main tasks which it set itself in the field of university teaching and research This year's discussions and lecture-demonstration programmes included a report on closed-circuit television relay experiments for 'overflow' lecture rooms, a survey of television university courses in the United States, and a demonstration of visual-aid equipment for the ideal lecture room Among other things, the Council is at present interested in liaison with the International Scientific Film Association, further exploration of a possible lectureship in film and continuance and improvement of the catalogue and journal

The present honorary secretary of the British Universities Film Council, Mr C J Duncan, of King's College, Newcastle, recently reviewed the short history of the Council in an address at Gottingen He rightly emphasized that the Council is a gathering of university representatives, brought together through a common interest in films for university purposes This at once makes clear the practical advantages of personal contacts developed between individuals in each university or college, and of the direct personal ways in which they can in turn infect their colleagues with their own enthusiasm for using or making films

However hampered by financial stringency—in a medium far less expensive than is commonly assumed—however different the rate of progress in member institutions, that keynote of enthusiastic co-operation has been a feature of the Council since its foundation in the autumn of 1948 A few months earlier, the Cambridge University Film Council had been set up and it was this body which called the first gathering of 'film representatives' from all universities and colleges The aims of the Council, as then laid down, have not materially changed since then, although the emphasis may have varied Briefly stated, these aims are the promotion of the production, distribution and use of films in university teaching and research The aims have been practically pursued in hard-working sub-committees which act as special reporting and planning bodies to the executive and the Council, which meets annually each year at a different university The tonic effect of the visits has already been noticed, for during the meeting, the host-university staff and students, and interested bodies from outside, are invited to attend demonstrations, exhibitions of equipment, and programmes of films of interest to universities Past chairmen have come from Cambridge, Edinburgh, the Imperial College of Science and Technology, London, and the Royal Technical College, Glasgow

The Council's membership has grown to include to-day, as full members, thirty-two institutions in Great Britain alone, with a good hope of soon enlisting in addition the new colleges of advanced technology (Loughborough is already a member of long standing) Among the Council's associate members are the Scientific Films Association, London , Shell Public Relations Department , the French Institute, London , and Eastman Kodak Co (Non-Theatrical Film Section), Rochester, New York Close contacts and visiting arrangements exist with Dutch, German, French and Polish organizations mainly devoted to research films This contact with foreign bodies is expanding and is promoted by members attending international gatherings, such as the annual congress of the International Scientific Films Association

Nearly all British universities and colleges have through their delegates participated in the work of the executive or its sub-committees With the help of the British Film Institute and the support of subscriptions from member universities, the Council collects and disseminates information and advises on suitable films, or relevant parts of films and related material Good liaison exists with organizations doing comparable work in education, research, industry and commerce The Council's library, centrally housed at the British Film Institute, contains films recommended by the Library Sub-Committee, but only a fraction of what would be desirable is in fact there The Catalogue, in the hands of an active and energetic sub-committee, conducted from Glasgow, already contains more than 1,500 titles , a card index is issued free to members and can be bought by others It consists mainly of films on pure and applied science, but no subject is ignored which is within the scope of a university Medical films are also listed, but the Committee tries to avoid duplication of the work of the Film Committee of the British Medical Association and related organizations Catalogues are, as a rule, easily accessible in university reference libraries, and many member institutions have as many as three copies in constant use Index cards are 2*d* each to non-members (minimum 5*s*), and a revised list was published early in 1957 The Council also publishes the *University Film Journal* about three times a year, which contains relevant articles of interest to staff and students in universities, important reprints and as much news material from home and overseas as possible At the time of writing, inquiries are being circulated throughout all member universities on the quality and kind of film needed by lecturers and professors, and what special film equipment is being held and would be available to colleagues

The Council has successfully sponsored special conferences on the use of films in such diverse fields as modern languages (at the Institut français), arts subjects (at the Institute of Education, London), chemical engineering (at Birmingham), psychology (at University College, London) , it has also, in the past, assisted in the selection of films for the annual British Association meetings J Horne

UNIVERSITIES AND ADULT EDUCATION IN BRITAIN

THE total number of courses conducted in Britain by university extra-mural departments during 1957–58 were rather fewer than during 1956–57, but still above the figure for 1955–56 Although this may give cause for modest satisfaction, the slight decline which took place was not evenly spread over the whole of the work but affected with disproportionate severity tutorial classes and residential courses, two branches of work which universities have traditionally cherished* Since the beginning of the current decade the tendency has been for the number of tutorial classes to decline, but the sharp drop during 1957–58 is without recent precedent

There are signs that the policy of financial limitation initiated a few years ago is now affecting extramural work, particularly in the type of course provided In such work it is difficult to stand still , an attempt to curb developments inherent in the work is apt to lead to retrogression Many extra-mural departments were just able to hold their own, or reported small increases in the number of classes (usually shorter classes) in spite of grant problems

At Glasgow it was reported that "during the past year some of the emergency cuts which had to be made, such as the reduction of the library grant, are likely to have a harmful effect on the quality of the work unless they can soon be restored" Nottingham had to reject ten requests from classes because of shortage of funds At Oxford also there were financial problems "The University Chest found itself forced to cut its grant for extra-mural work, with the result that the adult scholarship scheme was suspended and the number of classes fell more sharply than at any other university " The Delegacy for Extra-Mural Studies restated, in a memorandum submitted to the Hebdomadal Council, its firm belief in the value and importance of extra-mural studies, and "its regret that the work must be contracted at a time when the need for it had become even more urgent"

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* Universities Council for Adult Education Report on the year 1957–1958 Pp 28 (Bristol W E Salt, Hon Secretary and Treasurer, The University, 1959)

THE CENTRAL AGRICULTURAL RESEARCH STATION, CARAPICHAIMA, TRINIDAD

By Dr A J. VLITOS
Director

THE new Central Agricultural Research Station located at Carapichaima, Trinidad, is an institution intended to foster fundamental and applied research relative to sugar cane Supported by private funds (Caroni, Ltd , and Ste Madeleine Sugar Co , Ltd) the new Research Station is concerned with the agronomy, physiology, pathology, entomology, and biochemistry of sugar cane with the ultimate aim of applying in the field new information which may be forthcoming from the basic investigations

The main section of the Station houses the physiology, pathology, entomology, and biochemistry units in an air-conditioned laboratory, fully equipped with the facilities required to carry out the research programmes Adjacent to main laboratories are dark rooms and a temperature-controlled light room suitable for the growth of plants under controlled environmental conditions A library, containing the pertinent scientific journals, is located in the east wing of the main building

An agronomic programme, more applied in nature, will complement the fundamental studies in physiology A major effort is being directed towards the control of froghopper (*Aeneolamia varia saccharina*) and the other major insect pests of cane in Trinidad Chemical weed control, as well as new methods of cultivation, are also under investigation Physiological and biochemical studies are concerned with the auxin relations in the developing cane seedling, from seed to flowering In addition to the auxin studies, several investigations on mineral nutrition and photosynthetic efficiency will round out the physiology programme The pathology programme is devoted to a thorough study of the rhizosphere of sugar cane, including a taxonomic investigation of the microflora and microfauna residing in the immediate vicinity of the root system, as well as an analysis of the interrelationships between the secretions of the root system and the microbial population

THE LISTER INSTITUTE

THE report of the Governing Body on the work of the Lister Institute for 1959 describes a wide range of investigations* In the field of microbiology the Guinness–Lister Unit continues its exploration of the genetics of *Salmonella* bacilli, mainly in terms of the biochemistry and genic control of the synthesis and function of flagella, using the bacteriophages that infect these bacilli to transduce genetic material from one kind of bacillus to another The bacteriophage transduction technique has been extended to staphylococci The other purely biological study concerns the cytology of certain free-living, flagellated protozoa

Studies by Institute staff into the immunology and pathology of infective diseases are concerned with infections by viruses, pleuropneumonia-like organisms, bacteria and protozoa

The isolation of the viruses of trachoma and of inclusion blennorrhœa has opened up a large field of study, both in Gambian laboratories of the Medical Research Council's Trachoma Unit, where the epidemiology of trachoma is being studied, and in the Council's Unit in the Department of Virology The ready infection of the baboon's conjunctiva with the virus of inclusion blennorrhœa provides an experimental model in which to study the practicability of prophylactic immunization in the related infection by trachoma virus In the Smallpox Vaccine Department, there is continued progress towards making vaccine from vaccinia virus grown in tissue culture, as an alternative to virus harvested from the skin of infected sheep

The investigation of a bacterial urethritis in man established a genital type of pleuropneumonia-like organism as a possible cause In man, however, the incidence of antibodies to pleuropneumonia-like organisms was not correlated with the presence of the organisms in the genitalia, so a detailed study of the relation of the pleuropneumonia-like organism antibody response to infections by the organism is being made, in the first place in experimental infections of the rat

The immunological study of bacterial infections shows further progress in identifying the two antigens of the whooping cough bacillus responsible for prophylactic immunization and the exclusion of the histamine-sensitizing antigen as being immunogenic as well as a search for immunizing somatic antigens in the diphtheria bacillus and an analysis of the iota toxin of *Clostridium welchii*, a bacillus that may play an ætiological part in infective hæmorrhagic fever The study continues of the biologically active substances formed when diphtheria anti-toxins are refined by proteolysis, and of the actual enzymic process of refinement

With pathogenic protozoa, the antigenic analysis of *Trichomonas* species continues and a new field has been entered in an attack on the immunology of trypanosomiasis Soluble trypanosome antigens, formed during experimental trypanosomiasis of the rat, are under investigation and the *in vitro* culture of trypanosomes is being attempted to provide bulk material for antigenic analysis of these protozoa

The refined serological methods devised to identify the animal source of food for blood-sucking insects continues to provide valuable facts about the feeding habits of tsetse flies and mosquitoes in regions where these insects are vectors, or possible vectors, of disease

Work on the relation of early tissue reactions to defence against microbial infection continues The tissue response to various kinds of injury, including infection, was explored to determine the role, if any, of the serum proteases which increase capillary permeability The investigation of early non-specific resistance to bacteria was extended to infections by tubercle bacilli

The biochemical researches mainly concern three kinds of substances—the blood group substances, the cellular phospholipids and starches

During the year the problem of homogeneity of the blood-group specific substances isolated from secretions and digests of tissue has received careful attention and new methods of analysis have revealed that in the natural secretions blood specificity is associated with at least two types of mucopolysaccharide molecule Progress was made in the separation and purification of enzymes which destroy the serological activity of the blood-group substances, and the chemical changes associated with loss of activity were investigated

The phospholipid study is at present directed to defining the constitution of tissue phospholipids which, although ill-described, are known to be metabolically active The structure of one of these, cardiolipin, has been elucidated and work is proceeding on the fatty constituents of the plasmalogens and the polyglycerophosphates

The plant enzymes established as responsible for the synthesis and degradation of starch have been characterized in terms of their individual actions on starch These enzymes were studied particularly in respect of their combined actions in systems thought likely to reproduce the conditions in which starch is synthesized *in vivo*, and of their separate actions on chemically modified substrates, designed to yield information on the specificity of the enzymes

On human plasma proteins, the Institute's work is concerned with the isolation, refinement, characterization, assay and in some cases clinical trial of the various biologically active proteins of human plasma

The difficulties of specifying the potency of preparations of anti-hæmophilic globulins for use in hæmophiliacs has necessitated a re-examination of modes of assay; clinical studies of the efficacy of the human preparation are in progress The therapeutic value of γ-globulin in the treatment of hypogamma-globulinæmia is the subject of another clinical study Studies of the isolation of active proteins include that of plasmin for clinical use and the conditions of its activation from the precursor plasminogen during the fractionation of serum as well as that of oxidase cæruloplasmin Pathological studies include investigations of the so-called 'macroglobulins' that occur in hyperglobulinæmic sera and of the proteins that appear in the urine of man and animals poisoned by heavy metals

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* Lister Institute of Preventive Medicine Report of the Governing Body, 1959 Pp 34 (London Lister Institute of Preventive Medicine, 1959)

A THEORY OF THE ABRASION OF SOLIDS SUCH AS METALS

By J. GODDARD, H. J. HARKER and H. WILMAN

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ABRASIVE wear is particularly important in machine bearings and gears[1] as well as in the mechanical surfacing of metals. Nevertheless, hitherto there has been no adequate theory to account quantitatively for the observed friction and wear of metals during abrasion. In particular, no simple relation between wear and friction has been observed. We have now observed such a clear and interpretable relation (see equation 1, below), and this has led us to develop the theory outlined below, which accounts well for the abrasion phenomena in the case of metals and similar solids, where the deformation is mainly plastic.

As the hard abrasive surface we have used emery papers having a mean particle diameter of 5, 10, 15, 35, 45, 70, 100 and 150 microns (grades 0000 to 3) since these represent at least approximately defined degrees of roughness down to a fineness not easily obtained by machining. The metals (copper, silver, platinum, aluminium, iron, molybdenum, tungsten) were blocks having about 3 cm.² nominal bearing area, and these were slid at about 5 cm./sec. under loads (W) of up to 2 kgm. on these emery papers. Practically identical results were obtained with the emery either dry or wet with propyl alcohol, except in the case of aluminium, which showed negligible pick-up of emery when wet, but extensive pick-up and abnormally high friction when dry.

Figs. 1 (curves a and b) and 2 show, for example in the case of copper and tungsten, the typical variation of the coefficient of friction, μ, and the wear per unit distance, M, respectively, with the mean diameter D of the emery particles.

Spurr and Newcomb[2] made similar experiments, but with loading via a lever arm on which the specimen (3/16 in. diameter rod, but probably about 0.1 cm. diameter of bearing surface) was fixed, and under which the emery paper passed on a trolley. Instead of the form of variation of μ with D shown in Fig. 1 (curves a and b), with its fall at low D to a value close to that for the metal sliding on a similar metal surface, they concluded μ increased linearly with D, the rise ($\sim$ 0.1) being due to the ploughing component[3], μ_p, which was assumed to be zero at $D = 0$, and proportional to D. In our more general conditions we have used specimens of considerable length ($\sim$ 2 cm. for curves a and b in Fig. 1) in the sliding direction. We conclude that on the finer grades of emery (D small), only in a limited front region of the specimen bearing face are there effective contacts and indentations of the emery particles into the metal. This region is estimated to be only $\sim$ 0.1 cm. for 0000 emery, but it must increase (roughly proportionally) with increasing diameter of the abrasive particles. In the remaining rear part of the face, the metal is mainly in contact with metal which has been worn away from the front specimen region and is almost completely clogging the emery in the operative bearing areas. In agreement with our quantitative theoretical estimations, we find the variation of μ with D is much less (approximately that found by Spurr and Newcomb[2]) when a shorter copper specimen (0.18 cm.) is used, as in curve a' of Fig. 1.

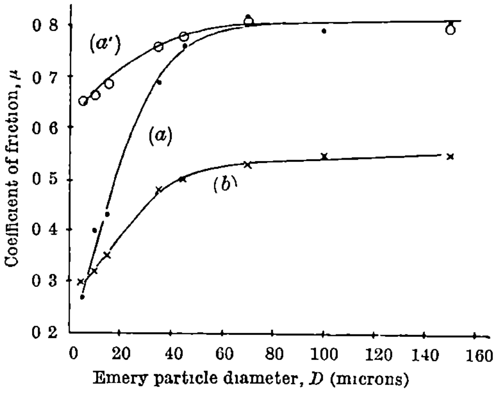

Fig. 1. μ for copper ●—●, 2 cm. specimen length, ○—○, 0.18 cm. specimen length, and tungsten ×—×, 2 cm. specimen length, sliding on various grades of emery paper

We find a corresponding form of variation of M with D (Fig. 2), also not previously described. The data of Figs. 1 and 2 also give Fig. 3, indicating an effectively linear variation of M with μ. Since M is also proportional to the load W, we have

$$M = kW(\mu - \mu_0) \qquad (1)$$

where k is a constant (different for different metals), and μ_0 is also a constant which we find is virtually identical with the coefficient of friction of two surfaces of the given metal sliding against each other at similar loading. (Experiments in this laboratory by P. V. K. Porgess, J. N. King and P. S. Dobson have shown, however, that for the non-metals graphite, molybdenum disulphide and sodium chloride, the M–μ locus is curved.)

In considering the abrasive process theoretically, we conclude that if the abrasive particles were

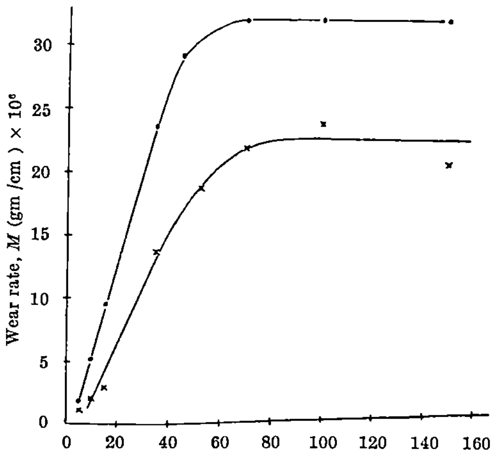

Fig. 2. Wear of 2 cm. copper and tungsten specimens on various grades of emery paper. ●—●, copper, 1 kgm. load; ×—×, tungsten, 2 kgm. load

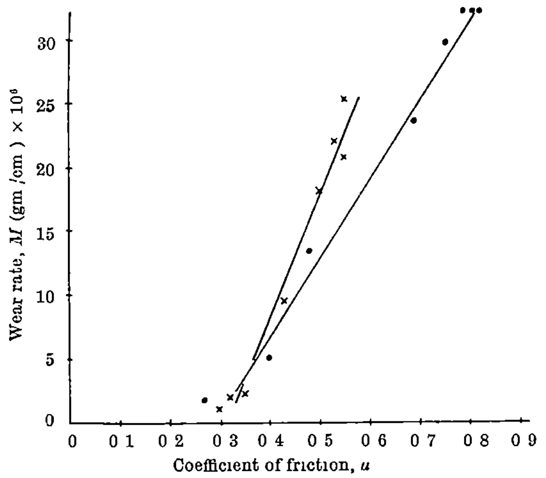

Fig 3 The linear variation of M with μ for the copper and tungsten specimens ×—×, tungsten, 2 kgm load, ●—●, copper, 1 kgm load

spherical, and all those contacting the metal shared the load equally, then μ would indeed be very small, the ploughing component μ_p being correspondingly small and of the order suggested by Spurr and Newcomb's results ($\sim$ 0 1), but that it would be practically constant, independent of D We find, in agreement with these views, that μ is, in fact, very small, $\sim$ 0 15 (and thus μ_p still smaller), for metals such as copper and silver sliding under 1–2 kgm load on a two-dimensional array of glass spheres of about 125 microns diameter ($\sim D$ for grade 2 emery) bonded on to a backing sheet (namely, "Scotchlite" reflective sheeting) Correspondingly, a negligible wear is observed in this case, although shallow, smoothly rounded grooves are formed, and little wear would be expected in view of the small inclination of the sphere surface to that of the metal near the contact, due to the low degree of indentation into the metal in the present conditions

On the other hand, for metals such as copper and silver sliding on a glass-paper or emery-paper sheet having this order of particle diameter ($\sim$ 125 microns), μ was high, $\sim$ 0 8, and practically independent of D for values of D between 50 and 150 microns We conclude (see below) that of this μ, μ_p is about 0 5, much higher than Spurr and Newcomb[2] suggested The wear rate was also high and approximately constant for D within this range The individual angular abrasive particles caused grooves in a smooth silver surface (sliding under 1 kgm load) largely by removal of more or less curved, waved or coiled strips of metal of length up to about ten times the groove width (which was $\sim$ 1/3–1/7 of D) These metal strips were often observed still integral with the metal at the front ends of the grooves The high μ and M that we observe in this range of D is thus evidently due to the emery (or glass) particles being mostly angular (as can be seen in the microscope) and not spherical

Theoretically, if n pyramidal or conical particles share the load W equally and are indented into the metal surface with their axes along the direction of the loading, then the sum of the areas of contact (between the particles and the metal) projected on to the plane normal to the loading direction must be constant and equal to W/p_m, where p_m is the maximum flow pressure of the metal Thus, n is determined by W and p_m, together with θ, the angle between the pyramid axis and one of the radial edges For square pyramids, azimuthally randomly oriented, we find that

$$\mu = \mu_p + \mu_a = (2/\pi)\,[\sqrt{2}(p'_m/p_m)\cot\theta + (s/p_m)\,(2\operatorname{cosec}^2\theta - 1)^{\frac{1}{2}}] \qquad (2)$$

and for equilateral triangular pyramids

$$\mu = \mu_p + \mu_a = (2/\pi)\,[2\ 25(p'_m/p_m)\cot\theta + 1\ 473\,(s/p_m)\,(1\ 333\operatorname{cosec}^2\theta - 1)^{\frac{1}{2}}] \qquad (3)$$

while for conical particles

$$\mu = \mu_p + \mu_a = (2/\pi)\,[(p'_m/p_m)\cot\theta + (s/p_m)\operatorname{cosec}\theta] \qquad (4)$$

where μ_a is the adhesion- or shear-component of μ, s is the tangential force required to shear unit area at the operative surface where shear occurs, and p'_m is the apparent p_m for forward ploughing against an increased pile-up of metal ahead of the moving particle We conclude that s/p_m is about 0 3, that is, about equal to the coefficient of friction of the metal (oxide) on the metal (oxide), that is, μ_0 Although $p'_m > p_m$, we can take these as approximately equal

To account for the observed maximum $\mu \sim$ 0 55 for tungsten (see Fig 1), the mean θ would thus have to be about 70° for square pyramidal particles ($2\theta = 140°$, minimum profile angle 125°) giving $\mu_p = 0\ 33$, 75° for triangular pyramidal particles (min profile angle 137°) giving $\mu_p = 0\ 37$, and 62° for cones (profile angle 124°) giving $\mu_p = 0\ 33$ This corresponds well to the sort of obtuse angularity of the particles mostly seen in the microscope This theory thus accounts well for the observed μ, which is much larger than for the case of the more shallowly indenting spheres, which approximate to cones of nearly 180° angle, that is, $\theta \sim 90°$

The constant value of μ observed at $D > 70$ microns appears, in general, to be smaller the harder the metal, for example, $\sim$ 0 78 for copper, nickel, silver and gold, 0 65 for platinum, $\sim$ 0 6 for molybdenum, chromium, iron, beryllium, and $\sim$ 0 55 for tungsten This variation is partly associated with the differing values of s/p_m (this variation is apparently small), but it appears to be mainly due to the ratio p'_m/p_m varying from 1 for the hard metals such as tungsten to $\sim$ 1 5 for the softer metals such as copper, silver and tin

The above model could be made more general by including the case of pyramids or cones having their axes inclined away from the direction of loading, but this would still be only an idealized approximation to the extremely complex actual case of irregularly shaped abrasive particles Our model shows, however, that in the absence of clogging, μ is independent of the particle size of the abrasive, and that μ_p forms the major part of the observed total μ

Now considering the wear rate, M, suppose a part, fW (where $0 < f < 1$), of the load W is supported on n identical emery particles, and the remaining load $(1 - f)\ W$ is supported on metal-to-metal contacts Let A_1 be the groove cross-sectional area (normal to the direction of sliding) A_0 being the equivalent part of this area corresponding to metal removed from the groove space but finally remaining on the specimen (for example, as the pair of piled-up ridges at the sides of the groove, and also as re-adhering wear particles) Then we conclude that

$$M = (fW\rho/p'_m)\ \alpha\ \{1 - (A_0/A_1)\}\,\mu_p \qquad (5)$$

$$= (W\rho/p'_m)\ \alpha\ \{1 - (A_0/A_1)\}\ [1 + (\mu - \mu_0)/\mu_p)^{-1}\ (\mu - \mu_0)] \qquad (6)$$

where ρ is the density of the metal, p'_m is the maximum flow pressure across A_1 to cause ploughing, and α is the fraction of the emery particles shaped and oriented favourably for producing wear particles. Comparing the observed linear form, Fig. 3 and equation (1), with this theoretical relation (6), shows that A_0/A_1 is independent of the emery particle diameter. Using an equation such as (2), (3) or (4) to express μ_p in terms of θ, equation (5) gives M directly in terms of θ and the properties of the metal, that is, ρ, p'_m, p_m, etc.

Since $M = \alpha n \rho (A_1 - A_0)$, and $nA_h = fW/p_m$, we may write as an alternative to equation (5) a more direct expression of M in terms of the properties of the metal

$$M/\rho = \alpha\ K(fW/p_m)\{1 - (A_0/A_1)\} \qquad (7)$$

$$= C\ (fW/H_D)\{1 - (A_0/A_1)\} \qquad (8)$$

where K is a constant defined as A_1 divided by the horizontal component A_h (that is, normal to the direction of loading) of the mean contact area per particle supporting the load during sliding—thus K depends on the shape of the particles; H_D is the diamond-pyramid indentation hardness number of the immediate surface region (which is very heavily work-hardened by the ploughing action of the abrasive particles); and C is a constant. Equation (8) shows that if A_0/A_1 is the same for all metals, at constant W, then

$$(M/\rho)\ H_D = \text{constant} \qquad (9)$$

Our results in Table 1 give an approximate check on the constancy of A_0/A_1 for various metals, using equation (7) to calculate $Mp_m/\rho W = \alpha K\{1 - (A_0/A_1)\}$, taking $f = 1$ and p_m = three times the ultimate tensile strength for the metal in a heavily work-hardened state (cf. $p_m \sim 90$ kgm./mm.² for copper)[3]. It is seen that $\alpha K\{1 - (A_0/A_1)\}$ is of the same order for copper, silver, platinum and iron. The small differences are probably due to the uncertainty of the value of p_m applicable to the work-hardened surface layer, and the more widely differing results for aluminium, molybdenum and tungsten seem likely to be mainly due to this uncertainty in p_m. Further circumstantial evidence of the constancy of A_0/A_1 for all pure metals is given by our interpretation of the results of Kruschov[4] (see below). The constant K depends on the shape of the abrasive particles and is ~ 0.5 in our case where $\theta \sim 60 - 70°$, and $0.5 < \alpha < 1$ from direct observation, and by consideration of the experimental $M/(\mu - \mu_0)$ values in the light of equation (6). The values of $Mp_m/\rho W$ in Table 1 thus indicate that $A_0/A_1 > 85$ per cent.

Table 1

Metal*	W	Mo	Fe	Cu	Ag	Pt	Al
Density (ρ) gm./cm.³	19	9	7.9	8.9	10.5	21.3	2.7
Ultimate tensile strength† kgm./mm.²	420	280	37	34	31	34	15
$M(f = 1)$ gm./cm. 10^{-6} ×	22	30	13‡	32‡	98	125	60§
$Mp'_m/\rho W = \alpha K \{1 - (A_0/A_1)\}$	0.07	0.14	0.02	0.04	0.04	0.03	0.05

* Measured Vickers hardnesses (kgm./mm.²) were: W, 456; Mo, 242; Fe, 100; Cu, 98; Ag, 73; Pt, 118; Al, 27.

† Data from "Handbook of Chemistry and Physics", 39th edn., pp. 2002 ff. (Chemical Rubber Publishing Co., Cleveland, Ohio, 1957–58); p_m is taken as $\sim 3 \times$ U.T.S.

‡ Results using 1 kgm. load, all others at 2 kgm.

§ Data using emery paper flooded with propyl alcohol; all other data for dry emery paper.

Khruschov[4] showed experimentally that for all metals in the annealed state (of hardness H_{DA}), sliding on the same grade of abrasive cloth (corundum particles $\sim 80\mu$ diameter) under the same load, the volume of wear per unit length, M/ρ in our notation, is proportional to $1/H_{DA}$. He further observed, however, for various metals that M is actually practically independent of the degree of work-hardening of the initial metal, and as he concluded, this shows that the process of abrasion work-hardens the surface region of the metal (which undergoes further abrasive wear) to about the maximum possible extent, though this maximum hardness, $(H_D)_{\max}$, was not defined. Our theoretical result (8), that (for not too small distances of abrasion) M/ρ should be proportional to the reciprocal of this hardness of the abraded surface, can be considered as showing, in conjunction with Khruschov's observation of $M/\rho \propto 1/(H_{DA})$, that this $(H_D)_{\max}$ is practically proportional to (H_{DA}) for all pure metals, the factor A_0/A_1 being also the same for all pure metals.

The work described has been carried out under the terms of the extra-departmental contract between the Mechanical Engineering Research Laboratory of the Department of Scientific and Industrial Research and the Imperial College of Science and Technology, University of London.

[1] Piggott, M. R., and Wilman, H., Paper 18, Conference on Lubrication and Wear, Inst. Mech. Eng., London, October 1957.

[2] Spurr, R. T., and Newcomb, T. P., Paper 28, Conference on Lubrication and Wear, Inst. Mech. Eng., London, October 1957.

[3] Bowden, F. P., and Tabor, D., "The Friction and Lubrication of Solids", 2nd edn. (Clarendon Press, Oxford, 1954).

[4] Khruschov, M. M., Paper 46, Conference on Lubrication and Wear, Inst. Mech. Eng., London, October 1957.

A CAPACITANCE METHOD FOR FOLLOWING VINYL POLYMERIZATIONS INITIATED BY γ-RAYS

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DILATOMETRY has long been accepted as the most satisfactory method of following the course of vinyl polymerization. The change in volume as the monomer polymerizes is measured by following the fall in the level of the monomer in a capillary tube using a cathetometer. Direct optical measurement is impossible when radiation is used for initiation, and although the use of a mirror system is sometimes feasible, parallax errors tend to reduce the accuracy of the method. Also, since polymerization reactions often require several hours for their completion, a continuous recording method is clearly desirable.

A dilatometer in which the capillary is filled with mercury was developed by Schultz and Harborth[1] to obviate difficulties in following the movement of the surface of highly viscous fluids, and later modified by Burnett for use under high vacuum[2], we have adapted this dilatometer by using the falling-mercury column as one plate of a condenser, the other plate being a sheathed metal rod parallel to the capillary Polymerization is followed by measuring the change in the capacity of this condenser using a commercially available capacitance bridge and feeding the output signal to a recorder The equipment has been designed for use with the radiation sources at Wantage Radiation Laboratory these have been described in detail by Dove, Murray and Roberts[3]

The sample is prepared in a breaker-seal tube under high-vacuum conditions and sealed off Above the breaker seal a B 7 socket is attached and the sample may be connected to the body of the dilatometer by means of this joint as shown in Fig 1 The bore of tap T_1 is filled with mercury, and with T_2 open and T_1 closed the apparatus is connected to the high-vacuum line and evacuated via the B 7 cone A Reservoir R_1 is filled with mercury and tap T_2 closed T_1 is then partly opened and the mercury in R_1 allowed to spray slowly into reservoir R_2 This procedure was found to 'flash off' any small quantities of air trapped in the mercury After the mercury has run into R_2, T_2 is opened cautiously and the mercury allowed to flow into the dilatometer until it reaches the level B The seal is broken by an upward movement of the breaker C, T_2 re-opened and mercury allowed to fill the entire vessel Air is allowed into the system above A, the reaction vessel removed from the high-vacuum line and reservoir R_1 detached A capillary tube of appropriate diameter fitted with a B 7 socket and with an earthing connexion sealed through it is held by two short lengths of rubber tubing against a $\frac{1}{8}$-in steel rod covered in polythene The polythene shield prevents fluctuations due to surface adsorption of water vapour by the capillary tube The steel rod has a small metal plate attached to one end for connexion to the capacitance bridge

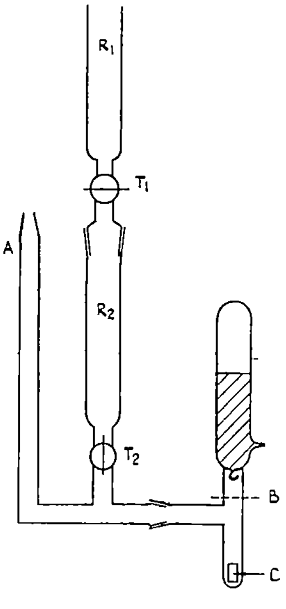

Fig. 1. Diagram of dilatometer

The capillary and fittings are shown in Fig 2 This capillary is connected by means of its B 7 socket to A picein wax is used to seal the joint By applying compressed air pressure above R_2 and opening T_2, mercury is forced through A into the capillary tube T_2 is then closed and the whole apparatus immersed in a water thermostat in the radiation source

It was found essential that the measuring capillary should be above the surface of the thermostat water, since otherwise a balance of the proximity meter could not be obtained, also, since stabilized glass tanks were not available, it was an advantage to have the capillary above the level of the thermostat tank so that the initial and final mercury-level could be accurately measured with a cathetometer

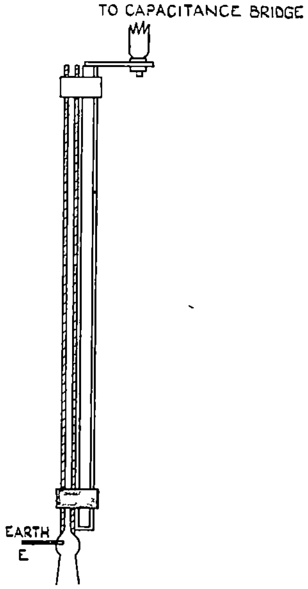

Fig 2 Capillary and electrode

Fig 3 shows the dilatometer in position The capacitance bridge used was a Fielden $PM2$ proximity meter (Fielden Electronics, Ltd, Wythenshawe, Manchester) This instrument offsets the large constant capacity of the system and measures only changes in capacity Since the length of the probe is only 6 ft the meter remains inside the radiation cell and is shielded by conventional interlocking 4-in lead bricks The sensitivity may be changed during the run if the fine sensitivity control is removed from the instrument case and mounted outside the cell This enables the first few per cent of reaction to be followed in detail at high sensitivity, if the sensitivity is then lowered an overall conversion curve may be obtained from the same sample To enable the proximity meter to be attached to a recorder, a 10-ohm resistance was put in series with the 1-m amp meter of the instrument and the voltage drop across this resistor fed to a Sunvic single-pen 10-millivolt recorder, clearly other values of this resistance may be chosen to suit any available millivolt recorder To obtain stable readings of the recorder it was found essential to earth the mercury and this was done by connecting E (Fig 2) to the earth of the mains Earthing of the thermostat tank, clamps and any other metal near the apparatus was found to be necessary A series of calibration graphs were made for various settings of the sensitivity control and various capillary diameters The dependence on sensitivity setting for a 1-mm capillary is shown in Fig 4 The use of narrower capillaries tends to lower the sensitivity of the equipment slightly In practice, initial and final mercury-levels were measured with a cathetometer in order to avoid any slight errors in the sensitivity setting

At Wantage the apparatus has been used to follow the emulsion polymerization of styrene and methylmethacrylate, and the preparation in emulsion of graft co-polymers of polystyrene and methylmethacrylate and poly-methylmethacrylate and styrene. It has also been used to follow the bulk polymerization of acrylonitrile and the graft polymerization initiated by gamma-rays of acrylonitrile on to poly-dimethylsiloxanes In use, the following precautions have been found necessary

(1) A stable power supply is required, and it is therefore advisable to supply the proximity meter from a voltage stabilizer Mains fluctuations at Wantage are exceptional, however, and this precaution may not be generally necessary (2) The proximity meter should be allowed at least 30 min to warm up before each polymerization run (3) It is essential to earth the mercury, the thermostat tank, source tube and other metal equipment near the capillary, to the instrument earth

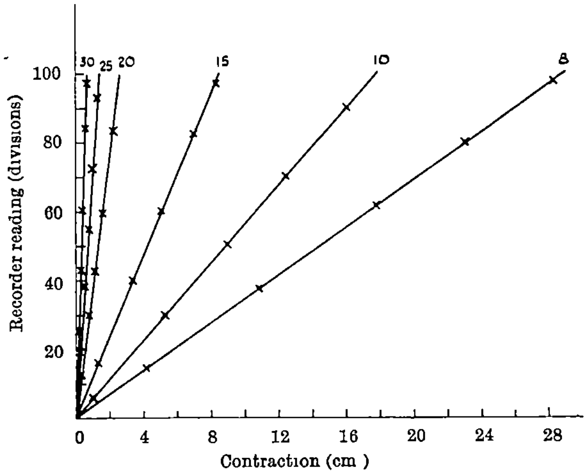

Fig 4 Calibration plot for 1 mm capillary

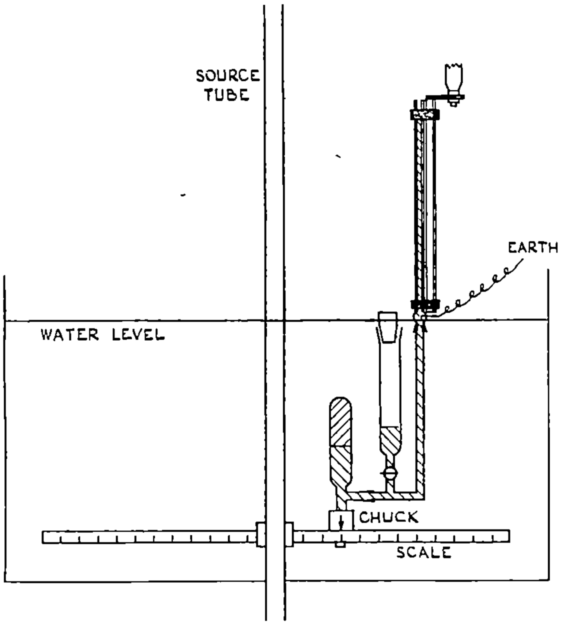

Fig 3 The dilatometer in position

The equipment has been used to measure contractions 0 6–30 cm in capillaries the diameters of which range from 2 mm to 0 5 mm The limit of 0 6 cm is imposed by the maximum sensitivity of the proximity meter Contractions greater than 30 cm have not been used in order to keep the size of the capillary small, and for contractions greater or less than these values for any given capillary, change in capillary diameter was used The limit of this process, so far as small contractions are concerned, appears to be the stability of the thermostat tank, since if the capillary is made too narrow, fluctuations due to the slight rise and fall in temperature of the tank, amounting to perhaps 0 01 or 0 02 deg C , are observed Greater sensitivity may also be obtained by increasing the diameter of the steel rod (Fig 2)

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[1] Schultz, G V , and Harborth, G , *Angew Chem* , 59, 90 (1947)
Burnett, G M , *Trans Farad Soc* , 46, 772 (1950)

[3] Dove, D , Murray, G S , and Roberts, R , U N E S C O International Conference on Radiation in Scientific Research, Unesco/N S / R I C /19

PRODUCTION OF COLICINE BY SINGLE BACTERIA

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COLICINES are bactericidal substances produced by certain strains of Enterobacteriaceae and active on others[1] Colicines in many respects resemble bacteriophages , but, unlike them, do not multiply in the cells they kill a single particle or molecule of colicine therefore does not produce a 'colony' (plaque) in the confluent growth of a sensitive strain, as does a single phage particle From the analogy with the production of phage by lysogenic strains it has been surmised that all the colicine produced by a colicinogenic culture, either spontaneously or after 'induction' by ultra-violet irradiation, is synthesized and released by a fraction of the bacterial population, and that these cells are in consequence non-viable No direct test of this hypothesis has been possible because colicine production has hitherto been tested only by observation on the antibiotic activity of mass cultures We have now demonstrated the release of colicine by individual bacteria. (i) through the production by single bacteria of small clear spots in the confluent growth of a colicine-sensitive strain , (2) by the bactericidal action of products released into micro-drops of broth by single colicinogenic bacteria isolated by micro-manipulator. The results obtained by these techniques support the above hypothesis.

The colicinogenic strains used were derivatives of *Salmonella typhimurium* strain *LT2* made colicinogenic by growth in mixed culture with colicinogenic *Escherichia coli* or *Shigella* strains[1], or by phage-mediated transduction[2]. The colicine-sensitive indicator strains were *E. coli* strain φ[3] and antibiotic-resistant mutants derived from it.

To demonstrate the clear spots caused by the colicine released by single bacteria we used a modification of the soft agar layer method used in phage work. 3 ml. of soft agar (0.35 per cent) seeded with about 10^8 cells of the indicator strain and about 10^4 cells of a young broth culture of *S. typhimurium* producing colicine *E*2[4] were poured on to a nutrient agar plate; after 5 hr. incubation at 37° about 100 small clear spots, 0.2–0.8 mm. in diameter, were visible in the confluent growth of the indicator strain. No such spots were produced by cells of a non-colicinogenic *Salmonella* strain, nor with an indicator strain resistant to colicines of the *E* group. Colicine *E*2 is destroyed by trypsin; crystalline trypsin (200 μgm./ml.) in the soft agar prevented the appearance of clearings. Although the spots looked like phage plaques, no lysis was observed when they were cut out and tested on a fresh plate of indicator bacteria.

It thus appeared that the clear spots resulted from the production of colicine *E*2, either by the colicinogenic bacteria inoculated, or, perhaps, by their descendants. The following results show that a clear spot can be produced by the colicine synthesized and liberated by a single bacterium.

Colicinogenic bacteria when plated with a streptomycin-resistant indicator in soft agar containing sufficient streptomycin to prevent their growth still produced some clear spots. Similar results were obtained with chloramphenicol. Furthermore, some clear spots were produced even when the colicinogenic cells had been killed by treatment with chloroform for 5 min. at 37° before inoculation. The number of clear spots produced in the presence or absence of streptomycin was directly proportional (about 1 per cent) to the number of cells of the colicinogenic strain incorporated into the soft agar layer. Blendor treatment, sufficient to break up any cell clumps, applied to the colicinogenic culture just before its inoculation into the soft agar, did not affect the number of clear spots produced. The number of clear spots appearing in the presence of streptomycin was 10- to 100-fold less than without it; this suggests that most of the clear spots formed in the absence of streptomycin are produced by bacteria which synthesize colicine on the plate, but that there are a few cells in the culture each of which at the time of plating already contains enough colicine to produce a clearing.

Clear spots were produced, either in the presence or absence of streptomycin, even when the colicinogenic cells had been grown in broth containing trypsin, provided the trypsin was removed by washing, or neutralized by soy-bean trypsin inhibitor, at the time of plating. As all free colicine in the inoculum culture was destroyed by the trypsin, the colicine causing a clear spot cannot have been adsorbed from solution by a cell of the inoculum culture, and released later, a hypothesis proposed by Frédéricq[5] to explain the small plaque-like clearings he observed when dilutions of a colicinogenic culture killed with chloroform were plated with a colicine-sensitive indicator strain; it now seems probable that these clearings, like those here reported, resulted from production of colicine by single bacteria.

In certain colicinogenic strains, colicine production is inducible by ultra-violet irradiation[1]. The number of clear spots produced by a strain colicinogenic for *E*2 was much increased by irradiation before plating; if cells irradiated for a time which reduced the viable count by about 70 per cent were plated in a streptomycin soft-agar layer 90 min. later, the number of clear spots which appeared was half or more of the total number of colicinogenic bacteria inoculated, determined in a counting chamber.

We propose the term 'lacuna' for the clear spots produced by the colicine released by a single bacterium, in distinction from a phage 'plaque'. The soft agar of an area 0.8 mm. in diameter contains about 6,500 colicine-sensitive bacteria at the time of inoculation; the presence of lacunæ of this size indicates that some colicinogenic bacteria liberate at least 6,500 bactericidal particles of colicine *E*2.

The production of colicine by individual bacteria has also been demonstrated by micromanipulative isolation. Cells of the colicine-sensitive indicator strain grew as non-motile filaments, easily distinguishable from the short motile cells of *Salmonella typhimurium*. Cells of the indicator strain inoculated into droplets of broth containing colicine *E*2 failed to multiply, and became abnormal in appearance, showing alternate bright and dim segments when examined by low-power dark-ground microscopy; cells of a colicine-*E*2-resistant mutant of the indicator strain multiplied normally in such droplets. To test the production of colicine by individual bacteria, a strain of *S. typhimurium* colicinogenic for colicine *E*2 was 'induced' by ultra-violet light and incubated for 30 min. at 37° in broth, containing trypsin (500 μgm./ml.) to inactivate extra-cellular colicine. The irradiated cell suspension was then introduced into a micromanipulation chamber, and each of a series of droplets of broth with trypsin inhibitor 2 mgm./ml. was inoculated with a single bacterium from the suspension; volumes of the suspension not containing any cells were added to control droplets. 2 hr. later the colicinogenic bacterium had multiplied in about 20 per cent of the droplets; in the remainder it had not multiplied but was still visible. The proportion of single bacteria able to multiply in the micro-drops agreed well with the survival-rate of the irradiated suspension inferred from the ratio of viable and total counts. Three to twenty cells of the indicator strain were then added to each droplet. In about 60 per cent of the droplets in which the colicinogenic bacterium had failed to multiply the indicator bacteria added later did not multiply and instead developed the characteristic abnormal appearance. In the remaining 40 per cent the indicator bacteria multiplied normally, as they did also in the control droplets which had received medium, but no bacterium, from the suspension of irradiated colicinogenic bacteria. In droplets in which the colicinogenic bacterium had multiplied, the indicator bacteria at first multiplied, showing absence of colicine, but later ceased to grow, presumably as a result of colicine being released by one or more of the large population of colicinogenic bacteria then present. About 50 per cent of the individual bacteria tested were shown by this method to release colicine; in platings from the same irradiated suspension the ratio of the number of clear spots to the total number of bacteria was about 6 10

The micromanipulation experiments described above indicated that all or nearly all the cells of an irradiated culture which release colicine *E*2 are non-viable To see whether this was also so for the spontaneous production of colicine *E*2, about 1,000 cells of a chloramphenicol-sensitive colicinogenic strain were plated in a soft agar layer of a defined medium containing chloramphenicol, together with a chloramphenicol-resistant indicator strain , the latter was nutritionally exacting, so that it could multiply to only a small extent in the defined medium provided After 5 hr incubation, twelve lacunæ were visible in the thin confluent growth of the indicator After overnight incubation about 1,000 small colonies of the nutritionally less exacting colicinogenic strain appeared, the chloramphenicol concentration having fallen, by diffusion into the base layer of agar, below the level required to inhibit its growth No colonies developed at the centres of the twelve lacunæ marked earlier It is concluded that the bacteria which produced these clearings by releasing colicine were unable to multiply

The production of lacunæ has been used for a number of other investigations which will be reported in detail elsewhere *Salmonella typhimurium* strains producing colicines *I*, *B*, *K* and *E*1 produce lacunæ, of sizes about the same as with colicine *E*2 When overnight broth cultures were tested in soft agar containing streptomycin the numbers of lacunæ produced per million bacteria plated were approximately colicine *E*2, 1,000 , *I*, 0 2 , *B*, 200 , *K*, 300 , and *E*1, 1,000 The ratio varied in cultures of different ages , for example, it increased 10-fold when an overnight culture of a strain producing colicine *E*2 was diluted in broth and incubated for 1 hr at 37° After ultra-violet irradiation the fraction of bacteria producing lacunæ increased to about 0 5 in strains producing colicines *E*1 and *E*2 , no increase was detected in a strain producing colicine *I*

We thank Prof P Frédéricq for the provision of colicinogenic strains

[1] Frédéricq, P , *Ann Rev Microbiol* , 11, 7 (1957)
[2] Ozeki, H , and Stocker, B A D , *Heredity*, 12, 525 (1958) (abstract)
[3] Gratia, A , *C R Soc Biol* , 93, 1040 (1925)
[4] Frédéricq, P , *C R Soc Biol* , 150, 1514 (1956)
[5] Frédéricq, P , *C R Soc Biol* , 144, 730 (1950)

PERMANENT SET, SUPERCONTRACTION, AND UREA-BISULPHITE SOLUBILITY—THE PROTON-TRANSFER NATURE OF SOME CHANGES IN KERATIN AND THE ANALOGY WITH MUSCLE CONTRACTION

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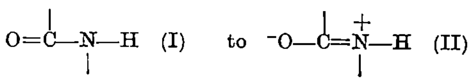
DURING the reaction of cystine residues in keratin with OH⁻ ions, sodium bisulphite, etc , the proportion of



$$\mathrm{O{=}\overset{|}{C}{-}\underset{|}{N}{-}H}\ \text{(I)}\quad\text{to}\quad \mathrm{{}^{-}O{-}\overset{|}{C}{=}\underset{|}{\overset{+}{N}}{-}H}\ \text{(II)}$$

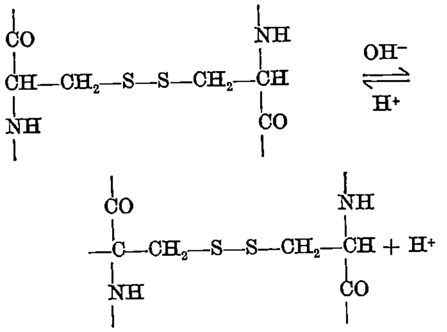
contributing to the resonance hybrid of the peptide groups hydrogen-bonded to each other in the protein network, and eventually to a carbonyl oxygen atom of the cystine residue, can alter An increase in the proportion of II (that is, an increase in the negative charge on the oxygen atom) will affect the strength of the hydrogen bonds between peptide groups electrostatically , also, it can be shown that an increase in the strength of the individual hydrogen bonds will follow as more peptide groups are attracted into the co-operating, hydrogen-bonded system The stability of permanently set keratin, and of keratin treated with alkali with a decreased solubility in urea-bisulphite solutions, seems likely to be caused by an increase in the strength of the hydrogen bonds between protein chains, caused in this way The analogy between muscle contraction and supercontraction of keratin suggests a mechanism of contraction of muscles containing sulphur in which disorientation and contraction of the muscle follows a weakening of the hydrogen bonds between peptide groups by reagents which react with sulphydryl groups Re-orientation of the muscle would follow an increase in the charge on the oxygen atoms of the peptide groups during the reverse reaction

In some early experiments on permanent set[1], a keratin fibre was extended in water and treated under tension with, for example, steam, boiling buffer solutions, or sodium sulphite solution The treated fibre was immersed without tension for an arbitrary period (1 hr) in boiling water, and if the fibre was to some extent stabilized in its extended form and its length remained greater than the initial length then it was said to be permanently set , if it was less, supercontraction had occurred Cross-linkages between the keratin chains are broken by the treatments, thus allowing the chains to rearrange in the stretched fibres If no new cross-linkages are formed then a change in the arrangement of the uncross-linked protein chains after immersion in boiling water causes supercontraction If new cross-linkages are formed in the treatments, then the chains are to some extent held in their positions in the extended fibre, thus causing permanent set A chemical treatment which decreases the solubility of keratin in urea-bisulphite solutions[2] is similarly most plausibly explained by new, resistant linkages between protein chains

Breaking of cystine disulphide bonds is an essential preliminary to permanent set in wool, but work in Australia on fibres containing reduced and alkylated cystine residues[3], and on the birefringence and contraction in lithium bromide solutions of set fibres[4], shows that it is an over-simplification to suggest that permanent set is entirely due to new covalent cross-linkages formed after reduction or hydrolysis of the cystine residues Two cross-linkages which have been directly confirmed in set fibres are lanthionine, thioether linkages, and re-formed cystine linkages, but these are not sufficient to account for the stability of permanently set fibres Some set remains after the fibres are treated without tension in boiling 5 per cent sodium bisulphite solution which will break re-formed cystine linkages, and Kessler and Zahn[5] point out that lanthionine derivatives are scarcely more stable than cystine towards the plumbite test for sulphur in acid or alkali, for example Lanthionine derivatives are also unstable in the urea-bisulphite reagent

The decreased solubility of alkali-treated wool in urea-bisulphite solutions cannot be explained by the formation of lanthionine cross-linkages or any other linkages derived wholly or in part from cystine, because it has been shown by Lees and Elsworth[2] and by Kessler and Zahn[5] that large changes in urea-bisulphite solubility occur before any change in the cystine content of the wool

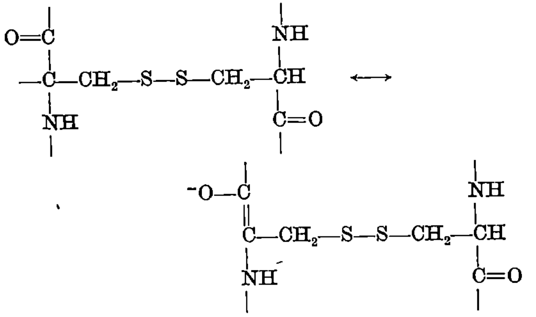
The work of Swan[6] with α, α′-dimethylcystine has shown that the first step in the alkaline hydrolysis of cystine is probably the ionization of a proton from an α-carbon atom



$$\underset{NH}{\overset{CO}{CH}}-CH_2-S-S-CH_2-\underset{CO}{\overset{NH}{CH}} \underset{H^+}{\overset{OH^-}{\rightleftharpoons}}$$

$$-\underset{NH}{\overset{CO}{C}}-CH_2-S-S-CH_2-\underset{CO}{\overset{NH}{CH}} + H^+$$

The negative charge on the cystine molecules will be divided between the α-carbon atom and the carbonyl oxygen atom, where it is inherently more stable, in a resonance hybrid



$$-\underset{NH}{\overset{O=C}{C}}-CH_2-S-S-CH_2-\underset{C=O}{\overset{NH}{CH}} \longleftrightarrow$$

$$\underset{NH}{\overset{^{-}O-C}{\overset{\|}{C}}}-CH_2-S-S-CH_2-\underset{C=O}{\overset{NH}{CH}}$$

If now the cystine residue is considered as part of a hydrogen-bonded protein network then the increased negative charge on the carbonyl oxygen atom following alkali treatment will induce a greater separation of charge on the co-operating, hydrogen-bonded peptide groups If proton transfer takes place between neighbouring peptide groups, these will change from the predominantly keto or lactam form to a predominantly enol or lactim form

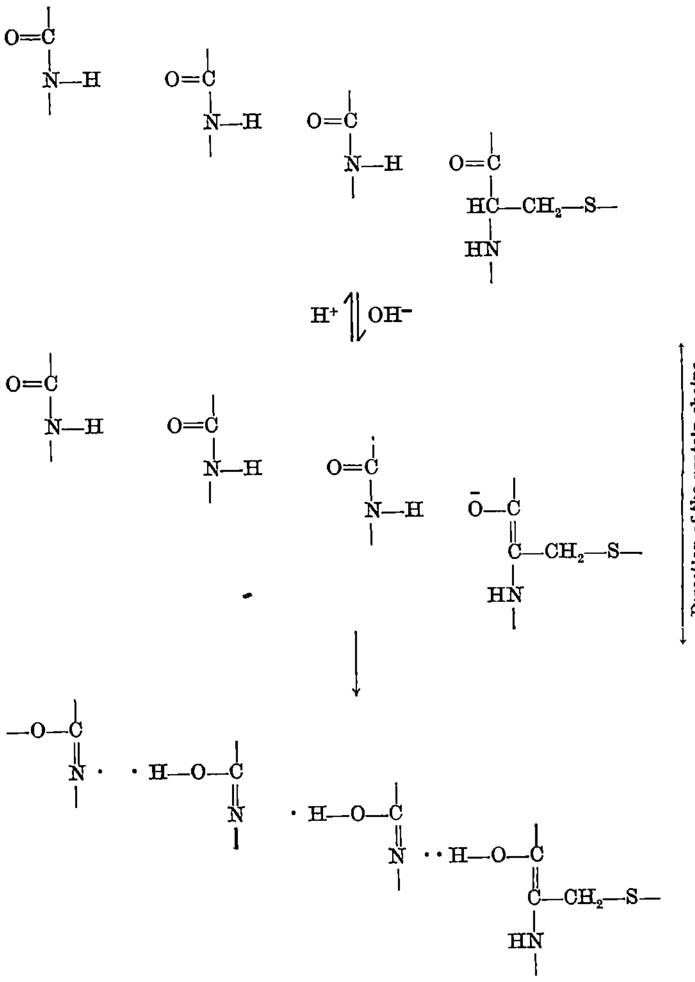


Fig 1

X-ray diffraction photographs show that an extended keratin fibre, treated with a setting reagent such as steam or boiling alkaline buffer solutions which will hydrolyse cystine residues, is set in the β, extended-chain, form, whereas an extended but untreated fibre returns slowly in water to the original α-helical form It is tempting, therefore, to suggest that in unset β-keratin the main protein-chain peptide groups are in the keto form, —CO—NH—, and in set β-keratin they are in the enol form, —C(OH) = N—, and that the hydrogen bonds in the enol form are stronger since set β-keratin is more stable The evidence for and against this theory follows

Evidence in favour (1) Only small shifts in the infra-red absorption frequency at the hydrogen-bonded NH stretching frequency of approximately 3,300 cm^{-1} are observed when set β-keratin is compared with α-keratin or other β-keratins[7], but 3,300 cm^{-1} is well within the range of OH stretching frequencies[8] when they are hydrogen-bonded thus O—H N Badger and Bauer[9] have pointed out that the difference in the frequency between the hydrogen-bonded and non-hydrogen-bonded OH stretching vibrations is related to the energy of the hydrogen bond The difference between the non-hydrogen-bonded OH frequency (3 700 cm^{-1}) and 3,300 cm^{-1} would indicate a fairly strong hydrogen bond which might account for the greater stability of set β-keratin compared with unset β-keratin

(2) The bond-angles and bond-lengths of Pauling's model of β-keratin[10] are deduced from the lengths and angles in amino-acid and simple peptide crystals These are in the keto form, but it might be equally possible to construct a model of β-keratin which would be compatible with the observed X-ray spacings from the dimensions and angles of the enol forms of peptides were these available In their absence, an approximate calculation can be made from Pauling's keto model In this model the CN bonds are inclined at an angle of 25° to the direction of the protein chain and have 40 per cent double-bond character If 60–70 per cent double-bond character is assumed in the enol form, this implies a bond 0 03–0 04 A shorter in length, so that the protein chain must shorten approximately 0 035 cos 25° A for each peptide unit = 0 032A The variation in length which would be caused by a change from keto to enol form might just be detectable experimentally assuming, as is likely, that no great change in bond-angles occurs and that the nitrogen atom remains sp^2 hybridized

Evidence against (1) Like the infra-red absorption at 3,300 cm $^{-1}$, the absorptions at 1,650 cm $^{-1}$ and 1,550 cm $^{-1}$ show only small shifts (25–30 cm $^{-1}$) when set β-keratin is compared with α-keratin and other β-keratins Fraser and Price[11], using Pauling's fractional bond orders, attribute the 1,650 cm $^{-1}$ absorption to an interaction between CO and CN frequencies The absorption at 1,550 cm $^{-1}$ is attributed to a coupling between an $\overset{\mathrm{N-C}}{\underset{\mathrm{O}}{\diagdown}}$ mode and an NH bending frequency By choosing the appropriate CO and CN bond orders it might be possible to devise an enolic NCO group to account for the 1,650 cm $^{-1}$ absorption, but it would seem to be stretching coincidence to suggest that one of the modes of the new NCO group would couple with an OH bending frequency to account for the 1,550 cm $^{-1}$ absorption

(2) A change from keto to enol form of the peptide groups would alter the length of the CO bond, and a further coincidence would be required since the protein backbone spacing in the β-form, which is related to the length of the interchain hydrogen bonds, NH . OC or N HOC, does not alter

(3) Lastly, Huckel[12] points out that the enolic forms of ketones are well known and that the keto/enol ratios can often be determined experimentally, but that no case is known where the enol or lactim form of an amide, *R*C(OH) = N*R*′, can be estimated or even shown unequivocally to exist Theoretical reasons are adduced to explain this in keto-enol tautomerism no movement of electrons can occur without proton transfer, in lactam–lactim tautomerism electrons can move in the group without proton transfer because of the lone pair on the nitrogen atom It may be that there is no energy barrier between the two forms so that the less stable form cannot exist Work on other hydrogen bonds has shown, for example, that the activation energy of the change O—H O → O H—O can be small or non-existent[13]

Thus, the possibility that in set β-keratin the peptide groups are in the enol form must be rejected Nevertheless, when cystine residues are in equilibrium with alkaline solution each must spend some fraction of its time in the ionized form before the dissociation postulated by Swan[6] takes place to an α-aminoacrylic acid residue and $^{-}$SSCH$_2$CHCONH— If the carbonyl oxygen atom of an ionized cystine residue is part of a hydrogen-bonded network its increased negative charge will have two effects, these are related to the bond-breaking and bond re-formation reactions in the original theories of supercontraction and permanent set

(1) An increase in the negative charge on the carbonyl oxygen atom of a cystine residue will induce a greater separation of charge in a peptide group hydrogen-bonded to it, increasing the positive charge on the nitrogen atom and the negative charge on the oxygen atom Similar charges will be induced in a second peptide group hydrogen-bonded to the first, and so on

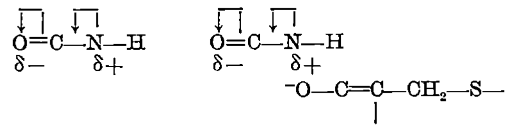


Fig 2

It is impossible to say from theoretical considerations whether these changes will increase or decrease the strength of the hydrogen bonds[8], but in the reactions of keratin considered here the hydrogen bonds appear to be weakened

(2) An induced, increased negative charge on the ultimate peptide carbonyl oxygen atom will attract further peptide groups into the hydrogen-bonded series of peptide groups which, in β-keratin, runs at right angles to the protein chains (Fig 1) and, in α-keratin, down the helices (Fig 3) Thus, with the aid of kinetic energy from the setting solutions, further peptide groups will be oriented into the α-helix of unextended keratin or the parallel chains of extended β-keratin An increase in the proportion of amino-acid residues in α-helices has been shown[14] to increase the optical rotation of a protein, so that the effect may be detectable using thin films sectioned from treated, unextended keratin fibres When

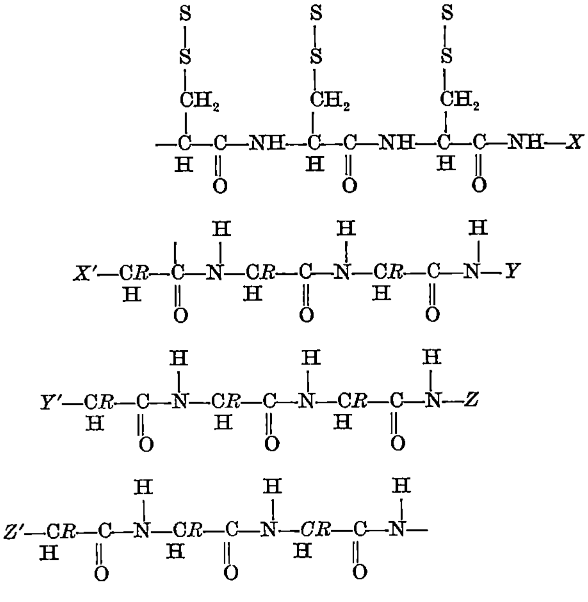
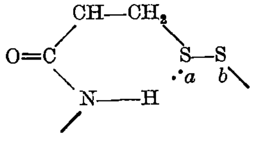


Fig 3 Diagram of the α-helical form of keratin (in the helix *X* is joined to *X*′, *Y* to *Y*′, etc) showing how three cystine residues can influence all the hydrogen bonds of the helix

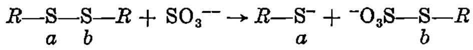
extended fibres are set, the X-ray diffraction photograph of set β-keratin, compared with unset β-keratin[15], shows a sharpening of the backbone reflexion, confirming the orientation of more protein chains into the strict β configuration. Davies, Evans and Lumley Jones[16], using methyl acetamide in carbon tetrachloride, have shown that the shift in the hydrogen-bonded NH vibration infra-red absorption frequency away from the non-hydrogen-bonded NH vibration frequency is increased from approximately 120 cm^{-1} to 190 cm^{-1} as the concentration of amide is increased. The shift can be attributed to an increase in the number of amide groups hydrogen-bonded together in each linear aggregate. The difference between the absorption frequencies of the NH vibration in non-bonded and hydrogen-bonded amide groups is proportional to the energy of the hydrogen bond, and therefore in the experiments of Davies, Evans and Lumley Jones the energy has been increased 60 per cent by increasing the number of co-operating hydrogen-bonded amide groups in each linear aggregate. Thus the stability of a hydrogen-bonded protein structure can be increased by bringing more peptide groups into the co-operating hydrogen-bonded system. If it becomes possible to examine the infra-red spectrum of unset β-keratin the NH vibration frequency should show a smaller shift from the non-hydrogen-bonded NH frequency than the NH vibration frequency in set β-keratin where, according to the present theory, the protein chains are oriented so that there are more co-operating peptide groups in each hydrogen-bonded series.

If the hydrolysis of cystine in steam, like the hydrolysis by OH$^-$ ions, involves ionization of a proton at the α-carbon atom, then the observed facts of steam setting are readily explained. At first, in the extended fibre, the hydrogen bonds are weakened by the increased polarization of the peptide groups. Immersion of the fibre without tension in boiling water after up to 15 minutes in steam causes supercontraction. Longer treatment in steam allows further orientation of the protein chains, and more co-operating peptide groups increase the strength of the individual hydrogen bonds, thus causing permanent set[15]. Treatment of extended keratin fibres in boiling borate buffer solutions[1] (*p*H 9·2) for 30 min. causes permanent set, orientation strengthening the individual hydrogen bonds. Less drastic treatment with phosphate buffers from *p*H 8 to 10 for 1 hr. at 50° C.[17] or 20 per cent potassium hydroxide solution at 28·5° C. for 3 min.[18] causes weakening of the hydrogen bonds by increased polarization of the peptide groups, without sufficient subsequent orientation to strengthen the hydrogen bonds, and thus supercontraction occurs under these conditions.

Swan[6] has shown that the hydrogen atom attached to the α-carbon of cystine is not involved in the reduction of cysteine by sodium sulphite. However, sulphur can take part in hydrogen bonding[19], and the most plausible hydrogen bond in cystine residues would seem to be:



The approach of a negative ion, SO$_3^{2-}$ or HSO$_3^-$, to sulphur atom *b* would induce a positive charge on *b* and a negative charge on *a*. In turn, the polarity of the peptide group would be increased. The negative charge on *a* will be further increased if the cysteine residue formed in the reduction is ionized, and in fact the setting reaction does appear to be catalysed by alkali[17]:



$$R\text{—}\underset{a}{S}\text{—}\underset{b}{S}\text{—}R + SO_3^{--} \rightarrow R\text{—}\underset{a}{S}^- + {}^-O_3S\text{—}\underset{b}{S}\text{—}R$$

The changes in the polarization of the peptide group and other peptide groups hydrogen-bonded to it will cause immediate weakening and eventual strengthening of the hydrogen bonds as in steam-setting and setting in alkaline solutions.

During the synaeresis of actomyosin after adding adenosine triphosphate, the X-ray diffraction pattern shows in certain conditions the appearance of a faint 'cross-β' reflexion which is typical of supercontracted keratin[20]. This suggests that there may be some similarity between the contraction of components of muscle containing sulphur and keratin supercontraction. Reaction with sulphydryl groups of muscle protein could alter the stability of the hydrogen-bonded network so that the chemical energy from a reversible, high standard free energy transphosphorylation, for example, liberated as kinetic energy, would cause disorientation of the protein structure and contraction. Then the reverse phosphorylation might induce negative charges on the peptide carbonyl oxygen atom and thus re-orient the muscle component into its original α-helical form.

This theory of permanent set, supercontraction, and urea-bisulphite solubility of keratin is put forward to explain those experimental facts[2-5] not fully explained by the early theories of permanent set[1,15]. There is no doubt, however, that all the chemical forces—covalent, electrovalent, van der Waals, and not merely hydrogen bonding—are involved in the three experimental phenomena considered.

I am grateful to Prof. W. T. Astbury for many suggestions during helpful discussions of this work.

[1] Speakman, J. B., and Stoves, J. L., *J. Soc. Dyers and Colourists*, **53**, 236 (1937).

[2] Lees, K., and Elsworth, F. F., Proceedings of the International Wool Textile Research Conference, Australia, *C*, 363 (1955).

[3] Farnworth, A. J., *Textile Res. J.*, **27**, 632 (1957).

[4] Feughelman, M., Haly, A. R., and Mitchell, T. W., *Textile Res. J.*, **28**, 655 (1958).

[5] Kessler, H., and Zahn, H., *Textile Res. J.*, **28**, 359 (1958).

[6] Swan, J. M., *Nature*, **179**, 965 (1957).

[7] Parker, K. D., quoted in "Synthetic Polypeptides", by C. H. Bamford, A. Elliott and W. E. Hanby, 405 (New York, 1956).

[8] Nakamoto, K., Margoshes, M., and Rundle, R. E., *J. Amer. Chem. Soc.*, **77**, 6480 (1955).

[9] Badger, R. M., and Bauer, S. H., *J. Chem. Phys.*, **5**, 839 (1937).

[10] Pauling, L., "Les Proteins", Institut International de Chimie Solvay, Brussels, 63 (1953).

[11] Fraser, R. D. B., and Price, W. C., *Nature*, **170**, 490 (1952).

[12] Huckel, W., "Theoretical Principles of Organic Chemistry", **2**, 557 (Amsterdam, 1958).

[13] Lippincott, E. R., and Schroeder, R., *J. Chem. Phys.*, **23**, 1099 (1955).

[14] Yang, J. T., and Doty, P., *J. Amer. Chem. Soc.*, **79**, 761 (1957); but see Downie, A. R., Elliott, A., and Hanby, W. E., *Nature*, **183**, 110 (1959).

[15] Astbury, W. T., and Street, A., *Phil. Trans. Roy. Soc.*, A, **230**, 75 (1932). Astbury, W. T., and Woods, H. J., *ibid.*, **232**, 333 (1933).

[16] Davies, M., Evans, J. C., and Lumley Jones, R., *Trans. Farad. Soc.*, **51**, 761 (1955).

[17] Speakman, P. T., *Biochim. Biophys. Acta*, **25**, 347 (1957).

[18] Bell, J. W., Veldsman, D. P., and Whewell, C. S., *J. Soc. Dyers and Colourists*, **74**, 85 (1958).

[19] Benesch, R., Benesch, R. E., and Rogers, W. I., in "Glutathione", ed. S. Colowick *et al.*, 31 (New York, 1954). Bellamy, L. J., Hallam, H. E., and Williams, R. L., *Trans. Farad. Soc.*, **54**, 1120 (1958). Boyer, P. D., in "The Enzymes", 2nd edit., ed. P. D. Boyer, H. Lardy and K. Myrback, 516 (Academic Press, New York, 1959).

[20] Pautard, F. G. E., *Nature*, **182**, 788 (1958).

INACTIVATION OF SOME ANIMAL VIRUSES BY HYDROXYLAMINE AND THE STRUCTURE OF RIBONUCLEIC ACID

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In the course of some studies on factors which might stabilize infectious ribonucleic acid isolated with phenol from animal viruses, it was found that hydroxylamine inactivates the infectious ribonucleic acid extracted from mouse encephalomyelitis virus (Table 1). In addition, several animal viruses, all of which contain ribonucleic acid, proved to be sensitive to hydroxylamine (Table 1).

Hydroxylamine may act on animal viruses by affecting (1) viral protein, (2) viral ribonucleic acid, or (3) both viral components. Several types of experiment were performed in order to locate the site of action of hydroxylamine. In the first type of experiment, mouse encephalomyelitis virus was treated with hydroxylamine and then ribonucleic acid was extracted. If hydroxylamine had reacted with the ribonucleic acid of the virus, then the extracted ribonucleic acid should be non-infectious. This type of experiment must be distinguished from that described in Table 1, where infectious nucleic acid is first extracted from virus particles and then treated with hydroxylamine. The experiments were carried out as follows. Mouse encephalomyelitis virus was incubated in 1 *M* hydroxylamine at 22° C and *p*H 7. A control preparation, containing no hydroxylamine, was incubated under the same conditions. The virus preparations were treated for various periods of time in the individual experiments. After dialysis of both samples, aliquots were assayed for virus infectivity to determine the virus survival ratio. The same samples were treated with phenol at 42° C to extract ribonucleic acid[1,2]. Infectivity of ribonucleic acid was titrated by intracerebral inoculation in mice. The ratio of the infectivities of ribonucleic acid extracted from treated virus to that extracted from control virus should be the same as the virus survival ratio if hydroxylamine inactivates the virus only by alteration of viral ribonucleic acid. Highly variable results were obtained, but the average virus survival ratio was only four times higher than the average survival ratio of the extracted ribonucleic acid. Considering the many manipulations involved in these experiments, the results indicate that hydroxylamine acts on mouse encephalomyelitis virus by altering the viral ribonucleic acid. This conclusion is also supported by the fact that mouse encephalomyelitis virus is inactivated at a rate comparable to that of infectious ribonucleic acid isolated from the virus (Table 1).

The second type of experiment to locate the site of action of hydroxylamine tested the effect of this compound on several activities of viral protein. A mouse encephalomyelitis virus preparation, inactivated by treatment with 1 *M* hydroxylamine at 22° C for 24 hr and then dialysed for 24 hr, had the same complement-fixing activity against a rabbit antiserum to mouse encephalomyelitis virus as a control preparation. Thus treatment of mouse encephalomyelitis virus with hydroxylamine results in an alteration of the infectivity of the ribonucleic acid without major alterations in the serological properties of the protein. In order to study the effect of hydroxylamine on other proteins of animal viruses, a fowl plague virus concentrate was treated with 1 *M* hydroxylamine for 24 hr, resulting in complete inactivation. After 24 hr dialysis, the hæmagglutinating activity was the same as that of a control. Further, the enzymatic activity of the virus, measured by elution from red blood cells at 37° C, was identical in treated and control preparations. The complement-fixing ability of the treated preparations was the same as that of the control, when measured with anti-fowl plague serum. Hence, as in the case of mouse encephalomyelitis virus, hydroxylamine had not caused any detectable changes in the viral protein, at least in the peripheral protein.

Table 1. THE INACTIVATION OF SOME ANIMAL VIRUSES AND ANIMAL VIRUS RIBONUCLEIC ACID BY HYDROXYLAMINE

A 4 *M* solution of hydroxylamine hydrochloride is adjusted to neutral *p*H by mixing with an equal part of 14 per cent sodium hydroxide. This solution is mixed with an equal part of infectious material and incubated for 15 min at 22° C. For the inactivation of viruses the reaction is stopped by 1 : 5 dilution in phosphate buffered saline (ref. 16) at 4° C, and excess hydroxylamine is removed by dialysis against phosphate buffered saline for 24 hr. For inactivation of infectious ribonucleic acid, the reaction is stopped and hydroxylamine removed by precipitation of the ribonucleic acid with alcohol. The virus infectivity was measured by plaque test (ref. 17) and the infectivity of ribonucleic acid from mouse encephalomyelitis virus was titrated by intracerebral inoculation in mice (ref. 1)

Infectious material	Survival ratio*
Infectious ribonucleic acid from mouse encephalomyelitis virus	2.6×10^{-2} 1.8×10^{-2}
Mouse encephalomyelitis virus	2×10^{-2}
Fowl plague virus	2×10^{-3}
Swine influenza	2×10^{-4}
Western equine encephalomyelitis virus	3×10^{-4}

* Titre of treated/titre of control

Hydroxylamine also inactivates certain bacterial viruses, but the action in this case is on a protein component, probably resulting in the rupture of thiol ester bonds in the protein of the tail fibres[3]. The activation energy of this process[3] is approximately 19 kcal./mole. To contrast this with the inactivation by hydroxylamine of animal viruses, the activation energy for the inactivation of western equine encephalomyelitis virus was determined over the temperature range 20–44° C. A value of approximately 4 kcal./mole was found. The difference observed in the activation energies for the inactivation of bacterial viruses and western equine encephalomyelitis virus indicates that different chemical processes may be involved in the two cases.

(*Note added in proof* The activation energy for inactivation of mouse encephalomyelitis virus is 15 6 kcal /mole Since mouse encephalomyelitis virus and mouse encephalomyelitis ribonucleic acid are inactivated at the same rate, this must be the energy associated with the reaction of ribonucleic acid with hydroxylamine This is similar to the energy for splitting thiol-ester bonds and may further suggest that an ester bond is split from ribonucleic acid by hydroxylamine The previously determined activation energy for inactivation of western equine encephalomyelitis virus may then represent a secondary reaction, perhaps an alteration of viral lipid)

A direct attack on the nature of the reaction of hydroxylamine with ribonucleic acid gave little positive information 'Model' ribonucleic acid was prepared from rat liver and calf liver by extraction with phenol at 4° C , using phosphate–citrate buffer at pH 5 in order to prevent the simultaneous extraction of deoxyribonucleic acid After alcohol precipitation, followed by precipitation with 1 *M* sodium chloride, the nucleic acid obtained consists of a two-component system with molecular weights $\sim 2 \times 10^6$ and $\sim 6 \times 10^5$, respectively (cf ref 4) This ribonucleic acid was treated with hydroxylamine for 24 hr or 48 hr and excess hydroxylamine was removed by repeated alcohol precipitation of the ribonucleic acid There was no degradation of ribonucleic acid, as revealed by analytical ultracentrifugation Further, paper chromatographic and paper electrophoretic studies of the products of alkaline and acid hydrolysis showed no differences from those of untreated ribonucleic acid Thus hydroxylamine does not seem to split the phosphate–sugar backbone of ribonucleic acid or alter any of the bases If one of these processes was responsible for the inactivation of infectious ribonucleic acid, which has a $1/e$ value of 3 7 min , meaning that an average of one such inactivating event has occurred in each molecule in 3 7 min , then approximately 400 such inactivating events would occur per molecule in 24 hr The failure to detect any changes after 24–48 hr with the methods used is strong evidence that inactivation did not occur by either of the above-mentioned processes As a comparative example, the oxidative deamination of adenine, guanine and cytosine in ribonucleic acid by nitrous acid can be demonstrated chromatographically after a reaction time of about 20 hr [5]

Recent studies on the chemistry of protein synthesis have shown that amino-acids are bound to a ribonucleic acid of low molecular weight (soluble-ribonucleic acid) before being coupled together in a polypeptide chain[6,7] The amino-acid is bonded to soluble ribonucleic acid at a 2′ or 3′ hydroxy-position of the terminal ribose and this amino acyl ester bond can be split by hydroxylamine[8] It could be that a similar structure exists in some forms of high molecular weight ribonucleic acid and that such a structure is essential for the biological activity of ribonucleic acid in those cases It would be difficult, however, to demonstrate the existence of an amino acyl ester in nucleic acid of molecular weight $\sim 2 \times 10^6$ since, by weight, the amino-acid represents ~ 1 part in 10^4 of nucleic acid Therefore, this hypothesis must be investigated by some indirect approach

One such approach is a comparison of the stability of the amino acyl-soluble-ribonucleic acid bond with that of the infectivity of ribonucleic acid from mouse encephalomyelitis virus (Table 2) The stability of infectious ribonucleic acid in the pH range 5–7 and the instability at pH 8 6 correspond to the pH stability of an amino acyl ester bond Control experiments on the degradation at pH 8 6 of 'model' ribonucleic acid from calf liver, measured by alteration of viscosity during a 48-hr period, showed that inactivation of infectious ribonucleic acid at pH 8 6 could not be due to alkaline hydrolysis of the phosphate–sugar backbone Hydroxylamine inactivation of ribonucleic acid from mouse encephalomyelitis virus proceeds more rapidly at pH 7 than at pH 5 5 and this is also true for hydroxylamine splitting of the amino acyl ester bond to soluble-ribonucleic acid[8] In contrast, the reaction of hydroxylamine with activated amino-acids (mixed anhydrides in which the carboxyl group of the amino-acid is phosphorylated)[9] occurs equally well[8] at pH 5 5 and pH 7 0 Therefore, if an amino-acid or related compound is linked to the ribonucleic acid of certain viruses, as suggested by these experiments, then the bond should be similar to that between amino-acids and soluble-ribonucleic acid (ester) rather than to that in activated amino-acids (mixed anhydride)

Table 2 A COMPARISON OF THE STABILITY OF AN INFECTIOUS RIBONUCLEIC ACID FROM MOUSE ENCEPHALOMYELITIS VIRUS AND THE AMINO ACYL ESTER BOND TO SOLUBLE-RIBONUCLEIC ACID

Infectious ribonucleic acid	Amino acyl ester soluble-ribonucleic acid bond
Stable at pH 5 60° for at least 10 min 22° for at least 15 min	Reported to be stable in 0 1 *N* HCl, as well as in the pH range 3–6 (ref 18)
Stable at pH 7 60° for at least 10 min 22° and 37° for at least 30 min	
Unstable at pH 8 6 37° for 30 min $n/n_0 = 0\ 03$	Unstable at pH 8 6, 37° Extrapolation of the data to 30 min $n/n_0 = 0\ 025$ (ref 19)
1 *M* NH_2OH, 22° $k^* = 0\ 25$ min^{-1} at pH 6 8 and 0 10 min^{-1} at pH 5 5	Reacts with 1 *M* NH_2OH at pH 7 to a greater degree than at pH 5 5 (ref 8)

* Assuming a first-order reaction, $dn/dt = -kn$, where n is the remaining activity at time t

Not all animal viruses can be inactivated with hydroxylamine under the conditions described here For example, Newcastle disease and mumps viruses, which are in one distinct sub-group of the myxoviruses[10], are resistant to 1 *M* hydroxylamine at 22° C Fowl plague virus and swine influenza virus, which belong to another sub-group[10], proved to be highly sensitive (Table 1) These results suggest that there are differences in the nucleic acids of these two groups of myxoviruses, although all myxoviruses which have been chemically analysed, including Newcastle disease[11], fowl plague[12], and influenza[13] viruses, contain ribonucleic acid Herpes simplex, which may contain deoxyribonucleic acid[14], also proved resistant to hydroxylamine The resistance of some viruses to hydroxylamine inactivation may be further evidence that hydroxylamine attacks a special configuration in the nucleic acid component of certain viruses, since it appears that all nucleic acids have certain chemical properties, such as a phosphate–sugar backbone, in common Thus it must be concluded that hydroxylamine does not alter any of the chemical bonds common to all nucleic acids

The biological significance of this hypothetical ester bonded to infectious ribonucleic acid is not clear One suggestion is that an amino acyl ester or some other acyl group in an ester linkage located at a terminal position on a ribonucleic acid chain would serve to limit the chain-length by providing the information that the end of the chain had been reached In any event, such a structure could serve to give the chain a direction in a more striking manner than that provided by the presence or absence of a terminal phosphate[15] Moreover, such a terminal ester group may serve as a priming agent for certain biosynthetic reactions

The theoretical and practical aspects of the phenomena described here are being investigated further and will be published in full detail elsewhere

We gratefully acknowledge the many stimulating discussions with Profs G C Mueller, W Schafer, G Schramm and R Dulbecco This work was supported by the Deutsche Forschungsgemeinschaft

[1] Franklin, R M , Wecker, E , and Henry, C , *Virology*, **7**, 220 (1959)
[2] Wecker, E , *Virology*, **7**, 241 (1959)
[3] Kozloff, L M , Lute, M , and Henderson, K , *J Biol Chem* , **228**, 511 (1957)
[4] Gierer, A , *Z Naturforsch* , **13*b***, 788 (1958)
[5] Schuster, H , and Schramm, G , *Z Naturforsch* , **13*b***, 697 (1958)
[6] Hoagland, M B , Zamecnik, P C , and Stephenson, M L , *Biochim Biophys Acta*, **24**, 215 (1957)
[7] Zamecnik, P C , Stephenson, M L , and Hecht, L I , *Proc U S Nat Acad Sci* , **44**, 73 (1958)
[8] Zachau, H G , Acs, G , and Lipmann, F , *Proc U S Nat Acad Sci* , **44** 885 (1958)
[9] Hoagland, M B , *Biochim Biophys Acta*, **16**, 288 (1955)
[10] Andrewes, C H , Bang, F B , and Burnet, F M , *Virology*, **1**, 176 (1955)
[11] Franklin, R M , Rubin, H , and Davis, C A , *Virology*, **3**, 96 (1957)
[12] Zillig, W , Schafer, W , and Ullmann, S , *Z Naturforsch* , **10*b***, 199 (1955)
[13] Ada, G L , and Perry, B T , *Austral J Exp Biol Med Sci* , **32**, 453 (1954)
[14] Newton, A , and Stoker, M G P , *Virology*, **5**, 549 (1958)
[15] Reddi, K K , and Knight, C A , *Nature*, **180**, 374 (1957)
[16] Dulbecco, R , and Vogt, M , *J Exp Med* , **99**, 183 (1954)
[17] Dulbecco, R , *Proc U S Nat Acad Sci* , **38**, 747 (1952)
[18] Hoagland, M B , Fourth International Congress of Biochemistry, Preprint, Symposium VIII (1958)
[19] Berg, P , and Ofengand, E J , *Proc U S Nat Acad Sci* , **44**, 78 (1958)

AUXIN AND THE BULBING OF ONIONS

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DETAILED studies of those changes in the internal morphology and histology of onion plants which are characteristic of the process of bulb development in response to the combined stimuli of long days and high temperature led to the formulation of a speculative hypothesis in terms of a supposed 'bulbing substance' or hormone[1] We are now engaged in a study of the changes in growth-substance content of onion plants during bulbing, using modifications of the methods of paper partition chromatography combined with bioassay of growth-substances first developed by Bennet-Clark *et al* [2,3] , we are also studying the effects of externally applied auxin on bulb development

When testing for an unknown chemical growth-factor supposed to produce a specific effect on a certain organ of an intact plant it is desirable, if possible, to develop an assay method depending on the production under standard conditions of such an effect in the same or similar tissue Thus one should, ideally test a fractionated tissue extract for the presence of a 'flowering hormone' by its capacity to cause flower initiation in growing points, preferably kept under otherwise non-inductive conditions , the appropriate test for growth-promoting hormones is one in which increase of growth is measured, rather than inhibition of growth, or abscission of organs , for a bulbing substance' the assay method should involve bulb development, again preferably under non-inductive conditions If this principle is ignored, as is frequently the case, irrelevant or misleading information may be obtained For the comparison of amounts of known compounds in tissue extracts from plants in different treatments, the use of assay methods depending on irrelevant plant responses would, however, seem to be justifiable if suitable precautions are taken to confirm that the compound concerned is in fact the one supposed

For bioassay we have therefore used a modification of the wheat coleoptile cylinder test[4] in an attempt to compare changes in the 3-indolylacetic acid content of onion plants during bulbing in long days with that of plants remaining in short days, but we have also developed a method in which onion seedlings constitute the test material and show an increase in 'bulbing ratio' (the ratio of the greatest diameter to the least) when supplied with a suitable growth substance in darkness The onion seedlings as used for this bioassay have been found not only to give a marked bulbing response to long days but also to externally applied 3-indolylacetic acid in darkness Seedlings at the 2-leaf stage of development, with roots and leaf-blades removed ('seedling sections'), rotated horizontally in darkness in a 1 per cent sucrose solution, show from 1 to 8 days an increasing bulbing ratio in the presence of added 3-indolylacetic acid (sodium salt, *p*H 7 0, at 1×10^{-4} *M* concentration, or approximately 20 p p m), whereas in sucrose alone there are no marked or consistent changes Such a response is rapid at 25° C , much slower at 20° C and almost non-existent at 15° C , this resembles the effect of temperature on rate of bulbing in response to the stimulus of long days[5] We have also found, with intact seedlings growing in water culture in short days, a small but statistically significant ($P < 0\ 02$) increase in bulbing ratio due to the addition of 1×10^{-4} *M* 3-indolylacetic acid to the solution, as compared with seedlings not given 3-indolylacetic acid.

We have made a preliminary survey of the changes, caused by various periods in long days at different stages of development, in the growth-substance content of onion plants For this purpose plants of variety Ebenezer were grown from sets in sand culture in short days (less than 12 hr) and transferred to long days (17 hr) at the time of expansion of the tenth, fourteenth, eighteenth and twenty-fourth leaf Samples were taken from long-day and short-day plants of the same age according to the plan shown in Table 1 Roots and leaf blades were removed and an ethanol extract made of the remaining tissue The method of fractionation was that of Bennet-Clark *et al* [3] and Larsen[6], except that the *p*H was brought to 2 5 with 20 per cent orthophosphoric acid Only the ether-soluble, acidic fraction has so far been investigated in detail Extracts were chromato-

Table 1

Days from start of long-day treatment	No. of leaves emerged at start of long-day treatment: 10	14	18	24
0	*P* 1, 2 *E* 1 H_2O 1	*P* 1, 2	*P* 1, 2 *E* 1, 3 *B* 1	*P* 1, 2
3	*P* 1, 2 *E* 1 H_2O 1	*P* 1, 2	*P* 1, 2 *E* 1, 3 *B* 1	*P* 1, 2
5	*P* 1, 2 *E* 1	*P* 1, 2		*P* 1, 2
7	*P* 1, 2 *E* 1	*P* 1, 2	*P* 1, 2 *E* 1, 3 *B* 1	*P* 1, 2
10		*P* 1, 2		*P* 1, 2
14	*P* 1, 2 *E* 1	*P* 1, 2	*P* 1, 2 *E* 1, 3 *B* 1	*P* 1, 2
21		*P* 1, 2	*P* 1, 2 *E* 1, 3 *B* 1	*P* 1, 2
28		*P* 1, 2	*P* 1, 2 *E* 1, 3 *B* 1	*P* 1, 2

Key to solvents used: *P*, *iso*-propanol (80)/water (10)/(ammonia 10); *E*, ethanol (80)/water (10)/(ammonia 10); *B*, *n*-butanol (80)/water (10)/(ammonia 10); H_2O, water.
Key to assay used: 1, wheat coleoptile straight growth; 2, colorimetric determination; 3, onion seedling section ('bulbing')

graphed and assayed, in the way indicated in Table 1, after being kept for not more than 48 hr. in darkness and at + 2° C. All chromatograms were cut into tenths before being assayed. Marker spots of 3-indolylacetic acid, run in the presence of onion extract and sprayed with ferric chloride–perchloric acid reagent[2], indicated the position in which 3-indolylacetic acid would be expected to occur. Making use of this information, the 3-indolylacetic acid content of the extract was estimated, in every case, by a modified Salkowski determination[7], after elution from a chromatogram with absolute ethanol. The growth promotion produced in the coleoptile tests by the sections of the chromatograms where 3-indolylacetic acid was expected to run was compared as between long-day and short-day plants and was also compared with that produced by known amounts of 3-indolylacetic acid run at the same time; thus a second, very approximate, estimate of the amount in the onion tissue was available. These results yielded the following information.

In short days a growth substance which ran on chromatograms in all the solvents tried at approximately the same R_F as 3-indolylacetic acid (added to onion extract) was almost always found. As estimated colorimetrically this amounted to about 2.5 mgm. 3-indolylacetic acid per kgm. fresh weight at the tenth leaf stage and 3–4 mgm./kgm. at the later stages investigated. The coleoptile tests suggested a more marked trend from about 0.2 mgm./kgm. at the tenth leaf stage to about 1.0 mgm./kgm. at the eighteenth and twenty-fourth leaf stages.

Following transfer to long days there was in all stages a rapid increase in 3-indolylacetic acid to a maximum at 3–5 days followed by a fall to a value below that for the short-day controls. The initial rise was greatest for the twenty-fourth leaf stage (Fig. 1), in which the maximum reached the high value of about 9.6 mgm./kgm. This was enough to give the characteristic colour with ferric chloride–perchloric acid spray. The estimate based on the coleoptile test was about 7.0 mgm./kgm. for the maximum in the long-day plants and was about 1.0 mgm./kgm. in short days.

The onion seedling section assay showed increases in bulbing ratio in the zone in which 3-indolylacetic acid would be expected to run; these indicated changes in '3-indolylacetic acid' content similar to those shown by the coleoptile test, that is, a steady moderate amount in the short-day plants and in the long-day plants an increase to a maximum at 3 days, followed by a fall to below the value for the controls by 14 days. There were no indications of any other 'bulbing substances'.

The possibility must be considered that some 'bulbing substance' other than 3-indolylacetic acid ran in approximately the same position on the chromatograms; it would, however, be unlikely to have the same R_F as this in all four solvents used, to produce similar effects both in wheat coleoptile growth and bulbing of onion seedling sections, and to give the distinctive colour reactions observed with the ferric chloride–perchloric acid spray and in the modified Salkowski determination. It is conceivable that a compound which was not 3-indolylacetic acid and which changed in concentration during bulbing became converted into 3-indolylacetic acid during the extraction procedure or during separation on the chromatograms; the latter possibility is rather discounted by the consistent result obtained with water as the running solvent and for the present the substance will be assumed to be 3-indolylacetic acid. If correct this is one of the few cases yet cited of a morphogenetic effect being associated with a known growth hormone.

It is worthy of note that in all the stages the 3-indolylacetic acid in the long-day plants had fallen to a value below that in the short-day controls by 14 days from the date of transfer—approximately the time at which a measurable increase in bulbing ratio first occurred under the conditions in which these plants were grown. Thus it appears that the swelling of the leaf bases characteristic of bulbing[1] can only be due to high 3-indolylacetic acid content as an after-effect; it might even be thought to be brought about by a sub-normal 3-indolylacetic acid level, but

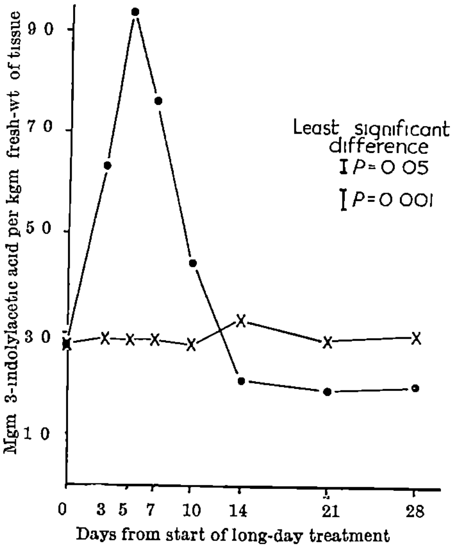

Fig. 1. Colorimetric determination of 3-indolylacetic acid content of plants at 24-leaf stage. ●—●, Long-day plants; ×—×, short-day controls

the onset and continuance of bulbing with a maintained external supply of 3-indolylacetic acid must be remembered here. The suppression of growth of the blades of the leaf initials, the first noticeable change in the internal morphology with the onset of bulbing[1], may be begun by the rise in 3-indolylacetic acid content, but it continues long after the subsequent fall. No account is here taken of possible differential distribution of the 3-indolylacetic acid and it is hoped to investigate this later.

This work is supported by the Agricultural Research Council, to which grateful acknowledgment is made, and much of it was carried out in the Research Institute of Plant Physiology of the Imperial College; it is being continued here and will be published in detail in due course. [March 12.

[1] Heath, O. V. S., and Holdsworth, M., *Soc. Exp. Biol. Symp.*, **2**, 326 (1948).
[2] Bennet-Clark, T. A., Tambiah, M. S., and Kefford, N. P., *Nature*, **169**, 452 (1952).
[3] Bennet-Clark, T. A., and Kefford, N. P., *Nature*, **171**, 645 (1953).
[4] Hancock, C. R., and Barlow, H. W. B., Rep. E. Malling Res. Sta., 88 (1953).
[5] Heath, O. V. S., and Holdsworth, M., *Nature*, **152**, 334 (1943).
[6] Larsen, P., *Physiologia plantarum*, **8**, 343 (1955).
[7] Gordon, S. A., and Paleg, L. G., *Physiologia plantarum*, **10**, 39 (1957).

A NON-DIALYSABLE INHIBITOR OF GLUTAMO-TRANSFERASE PRESENT IN EXCISED TOMATO ROOTS

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EXCISED tomato roots grown with either nitrate or ammonium as nitrogen sources accumulate the amides, glutamine and asparagine[1]. Attempts to study the mechanism of glutamine synthesis, by using homogenates of 21-day-old cultured roots, has led to the detection and partial purification of a natural non-dialysable inhibitor of the glutamo-transferase reaction.

Glutamine synthetase[2] promotes, at almost similar rates, the reaction of L-glutamate with either ammonia or hydroxylamine leading to the formation, respectively, of glutamine and γ-glutamylhydroxamate. Adenosine triphosphate and Mg^{++} (or Mn^{++}) are essential cofactors; maximal activity is obtained by the further addition of cysteine. Highly purified preparations of glutamine synthetase show[3], in presence of the metal activator, adenosine-diphosphate, and either phosphate or arsenate, glutamo-transferase activity:

$$\text{glutamine} + NH_2OH \rightarrow \gamma\text{-glutamylhydroxamic acid} + NH_3$$

It is possible, therefore, to use this reaction as an index of glutamine synthetase activity in crude preparations containing adenosine triphosphatase and to determine the hydroxamic acid formed by a colorimetric method[4].

A pea meal homogenate (5 gm. meal to 15 ml. water), partially clarified by centrifuging at 2,000 r.p.m. for 15 min., was used as the source of glutamo-transferase in the exploratory experiments first described. The standard reaction mixture (2.5 ml.) for assay of glutamo-transferase activity contained: 0.5 ml. 0.1 *M* *tris* buffer (*p*H 7.2), and 0.1 ml. of each of the following: manganese sulphate (0.01 *M*), sodium arsenate (0.1 *M*), sodium-adenosine triphosphate (0.001 *M*), L-glutamine (0.1 *M*), hydroxylamine (0.1 *M*, adjusted with sodium hydroxide to *p*H 7.2). The standard reaction time was 3 hr. at 35° C. Under these conditions the pea meal preparation produced, on different occasions, 3.6–4.8 μmoles glutamylhydroxamate.

Clones of excised tomato roots (*Lycopersicum esculentum*, Mill. var. Sutton's Best-of-All) were cultured in penicillin culture flasks containing 1 l. of a modified Whites's medium[5]. Twenty 10-mm. root tips, from sector cultures, were introduced into each culture flask and growth allowed to proceed for 21 days at 27° C. Root homogenates (1 gm. fresh wt. roots to 3 ml. water), prepared from different clones, uniformly lacked glutamo-transferase activity but differed in the extent to which they inhibited the transferase of the pea meal preparation when 0.5 ml. aliquots were incorporated in the standard reaction mixture. Homogenates from 15-day-old seedling roots of the same variety of tomato had low inhibitory activity and the inhibitory activity of the excised root clones rose to a steady value during the early subcultures following initiation.

The nitrogen source of standard Whites's medium is nitrate (45 mgm. nitrogen/l.) and its *p*H is 4.6. Homogenates of roots grown, respectively, with nitrite[6] (7.0 mgm. nitrogen/l. at *p*H 6.0), ammonium[6] (4.5 mgm. nitrogen/l. at *p*H 6.8), or L-glutamine (4.8 mgm. nitrogen/l. at *p*H 6.8) as nitrogen sources were also tested for their inhibitory activity, the homogenates being prepared at a strength (1 gm. fresh wt. roots to 5 ml. water) such that 0.5 ml. homogenate from the nitrate-grown roots of the clone produced about 50 per cent inhibition (Table 1).

Table 1. INFLUENCE OF NITROGEN SOURCE ON THE INHIBITORY ACTIVITY OF ROOT HOMOGENATES

Nitrogen source for root growth	Glutamylhydroxamate (μmoles)
No homogenate added	4.50
Nitrate	2.34
Nitrite	2.70
Ammonium	2.07
L-Glutamine	0.68

Two excised tomato root clones (clones 1 and 2) were used in further study of the inhibitor. Its solubility differed in the two clones. When the homogenate of clone 1 was centrifuged, the clear supernatant had very low activity and the inhibitor was liberated from the tissue residue by treatment with 0.1 *M* arsenate for 1 hr. (by repeated extraction in this way most of the activity could be removed from the residue). Clone 2, by contrast, yielded a supernatant of high activity, and little further activity was extracted from the residue by a single arsenate treatment (Table 2).

Using the total homogenate of clone 1 roots it was shown that, when added to the reaction mixture after 3 hr. incubation, it stopped the transferase reaction, but during 5 hr. further incubation did not decrease the hydroxamic acid content. The soluble inhibitory

Table 2. DISTRIBUTION OF INHIBITORY ACTIVITY IN ROOT HOMOGENATES

Addition (0·5 ml.) to reaction mixture	Glutamylhydroxamate (μmoles) Clone 1	Clone 2
Water	4·26	3·75
Supernatant	3·83	0·84
Arsenate extract of residue	0	3·58
Tissue residue	0	0
Residue after ten extractions with arsenate solution	3·94	

activity of the primary supernatant (clone 2) or of the arsenate extract (clone 1) was thermolabile (Table 3). These solutions did not decrease in activity when dialysed against distilled water for 48 hr. and were free from detectable proteolytic and adenosine triphosphatase activity.

Table 3. THERMOLABILITY OF THE SOLUBLE GLUTAMO-TRANSFERASE INHIBITOR OF CLONE 2 ROOTS

Time (min.) of exposure of inhibitor solution to 100° C.	Glutamylhydroxamate (μmoles)
0	0
5	0·8
10	1·2
15	2·5
30	3·7
45	4·5
60	4·5
Water control	4·65

A purified preparation of the glutamo-transferase enzyme was at this point obtained from 2 kgm. dried pea meal (*Pisum sativum* var. Meteor) by the method of Elliott[7], dissolved in the *tris* buffer, and the sensitivity of both the transferase and the synthetase activities of the enzyme to the tomato root inhibitor tested. The standard reaction mixture (3·3 ml.) used in assaying glutamine synthetase activity contained 0·5 ml. 0·1 M *tris* buffer (pH 7·2), 1 ml. enzyme solution, 0·5 ml. sodium-adenosine triphosphate (0·05 M), 0·5 ml. sodium glutamate (0·5 M), 0·1 ml. manganese sulphate (M), 0·1 ml. hydroxylamine (M and adjusted to pH 7·2), and 0·1 ml. cysteine (M). In these tests a partially purified preparation of the inhibitor was used. This was prepared from a clone 2 root homogenate (100 gm. fresh wt. roots to 200 ml. water) as follows: the supernatant was treated with 300 ml. acetone and the precipitate collected by centrifuging, washed with acetone and reduced to a dry powder in a vacuum desiccator. Half the acetone powder dissolved in 50 ml. water was treated with an equal volume of saturated ammonium sulphate solution and the precipitate collected by centrifuging and dissolved in water. This solution was dialysed at 2–5° C. for 48 hr. and then adjusted to 50 ml. The preparation of an active acetone powder ensured inactivation of any glutaminase[8] or adenosine triphosphatase[9] contamination. The inhibition, by the purified inhibitor, of the transferase activity of the pea meal enzyme is shown in Table 4.

Inhibition of the transferase activity by the purified inhibitor was not reduced by addition of 0·05 M cysteine or glutathione. Its inhibitory activity was maximal if incubated with the pea enzyme for 10 min. before adding substrates and cofactors. Prolongation of this preincubation for 60 min., using an inhibitor addition causing about 50 per cent inhibition, did not lead to any further decrease in enzyme activity. The inhibition was only slightly reduced by increasing the concentrations of glutamine or adenosine triphosphate in the reaction mixture (Table 5). There was no evidence that the inhibitor reduced the effective concentrations of Mn^{++}, arsenate or hydroxylamine.

Table 4. ATTEMPTED PURIFICATION OF THE GLUTAMO-TRANSFERASE INHIBITOR PRESENT IN EXCISED TOMATO ROOTS

Inhibitor fraction	Dry wt. inhibitor required to cause 50 per cent inhibition of transferase activity (μgm.)
1. Original supernatant	1,200
2. Acetone powder	450
3. Dialysed ammonium sulphate precipitate	76

Table 5. EFFECTS OF L-GLUTAMINE AND ADENOSINE TRIPHOSPHATE CONCENTRATIONS UPON THE PERCENTAGE INHIBITION OF GLUTAMO-TRANSFERASE ACTIVITY BY THE PARTIALLY PURIFIED TOMATO ROOT INHIBITOR

	Glutamylhydroxamate formed (μmoles)		
L-Glutamine (mM)	Inhibitor omitted	Inhibitor present	Percentage inhibition
4	2·4	1·14	53
8	4·0	2·2	45
12	5·7	3·4	41
20	8·1	4·95	39
ATP(M)			
10^{-5}	0·6	0·24	60
4×10^{-5}	2·1	0·90	57
10^{-4}	3·4	1·5	55
4×10^{-4}	3·8	1·9	50
10^{-3}	3·6	1·9	47

The inhibitor was active against both the transferase and the synthetase activity of the pea meal enzyme (Table 6).

Table 6. ACTIVITY OF THE PARTIALLY PURIFIED INHIBITOR AGAINST THE TRANSFERASE AND SYNTHETASE ACTIVITIES OF THE PEA MEAL ENZYME

	Glutamylhydroxamate formed (μmoles)		
Enzyme activity	Inhibitor omitted	Inhibitor present	Percentage inhibition
Glutamo-transferase	4·70	1·03	78
Glutamine synthetase	6·31	2·77	56

Homogenates of seedling roots of pea (*Pisum sativum* var. Meteor) also showed inhibitory activity, but it could not be detected in red clover roots (*Trifolium pratense* var. Dorset Marlgrass), and seedling roots of *Avena* (var. Victory) showed high glutamo-transferase activity.

Acknowledgment is made to the University College of Swansea for a research fellowship and to the Indian Institute of Science for the leave of absence which enabled one of us (C. S. V.) to undertake this work, to Prof. H. Waelsch of Columbia University for a pure sample of glutamylhydroxamic acid and to Imperial Chemical Industries, Ltd., for a grant towards the purchase of the Unicam spectrophotometer (*SP* 500) used in the estimation of the hydroxamic acid.

[1] Fletcher, B. H., Ph.D. thesis, University of Wales (1958).

[2] Elliott, W. H., *Nature*, **161**, 128 (1958); *Biochem. J.*, **49**, 106 (1951). Speck, J. F., *J. Biol. Chem.*, **168**, 403 (1947); **179**, 1405 (1949).

[3] Varner, J. E., and Webster, G. C., *Plant Physiol.*, **30**, 393 (1955). Levington, L., Meister, A., Hogeboom, G. H., and Kuff, E. L., *J. Amer. Chem. Soc.*, **77**, 5304 (1955).

[4] Lipmann, F., and Tuttle, L. C., *J. Biol. Chem.*, **159**, 21 (1945).

[5] Hannay, J. W., and Street, H. E., *New Phytol.*, **53**, 68 (1954).

[6] Sheat, D. E. G., Fletcher, B. H., and Street, H. E., *New Phytol.* (in the press).

[7] Elliott, W. H., *J. Biol. Chem.*, **201**, 661 (1953).

[8] Lipmann, F., and Kaplan, N. O., *J. Biol. Chem.*, **174**, 37 (1948).

[9] Mayerhof, O., and Junowicz-Kocholaty, R., *J. Biol. Chem.*, **145**, 143 (1942).

FORTHCOMING EVENTS

Monday, September 21

Institute of Metal Finishing (at the Northampton Polytechnic, St John Street, London, E C 1), at 6 15 p m —Mr A O F Freund and Mr A H Barber "The Use of Titanium in Electrolytic Processes for Metal Finishing"

Thursday, September 24

Oil and Colour Chemists' Association (at Manson House, 26 Portland Place, London, W 1), at 7 p m —Mr J A L Hawkey "A Technologist's View of 'The Fourth Epoch' "

Friday, September 25

Hospital Physicists' Association (in the Lecture Theatre, Main Medical School, King's College Hospital, Denmark Hill, London, S E 5), at 8 30 p m —Prof D G Catcheside, F R S "The Influence of Nutrition on Mutation Induced by Radiation" (Sixth Douglas Lea Memorial Lecture)

Wednesday, September 30

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W C 1), at 6 30 p m —Mr W E Willshaw "Modern Microwave Valves—a Survey of Evolution, Principles of Operation and Basic Characteristics"

Thursday, October 1—Friday, October 2

Institute of Biology (in the Lecture Hall, Royal Geographical Society, Kensington Gore, London, S W 7), at 10 a m daily—Symposium on "Biological Problems Arising from the Control of Pests and Diseases"

Society of Chemical Industry, Food Group (at the Royal Society of Medicine, 1 Wimpole Street, London, W 1)—Symposium on "Enzymes in the Manufacture, Storage and Distribution of Food"

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned

Research Assistant (preferably graduate in mathematics and experience in the use of digital computers) in the Computing Laboratory, to assemble and run programmes using the Interpretative Schemes in the Deuce Computer—The Secretary of University Court, The University, Glasgow (September 28)

Assistant Lecturer in Botany—The Registrar, The University, Manchester 13 (September 30)

Technical Assistant (qualified to maintain and supervise the use of X-ray apparatus and the electron microscope) in the Houldsworth School of Applied Science—The Registrar, The University, Leeds (September 30)

Lecturer in Philosophy—The Secretary, The University, 38 North Bailey, Durham (October 1)

Lecturer in the History of Science—The Registrar, The University, Leicester (October 1)

Research Assistant (graduate) in the Department of Agriculture, to carry out investigations into the efficiency of farm buildings by the application of work study methods—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (October 1)

Lecturer or Senior Lecturer in Physics and/or Chemistry, to take subject to Pass Degree standard—The Principal, Bede College, Durham (October 3)

Reader or Senior Lecturer (with experience in experimental physics, and preferably experience in some aspects of applied physics) in the Department of Physics of the Faculty of Science—The Registrar, The University, Manchester 13 (October 5)

Lecturer (with special qualifications in hydrography) in Geography—The Registrar (Room 22, O R B), The University, Reading (October 10)

Chair of Physics, Chair of Chemistry, and Chair of Biology in the Royal University of Malta—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W C 1 (October 15)

Lecturer or Assistant Lecturer in Bacteriology at the University of Malaya (Singapore Division)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W C 1 (October 15)

Lecturer (with a qualification in biochemistry and preferably with a medical qualification) in Chemical Pathology—The Dean, St Thomas's Hospital Medical School, London, S E 1 (October 15)

Lecturer or Assistant Lecturer in Physics at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W C 1 (October 20)

Lecturer in Microbiology in the Faculty of Rural Science, University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 23)

Lecturer in Nutrition in the Faculty of Rural Science, University of New England, Australia, to undertake teaching and research in livestock nutrition in the Department of Nutrition and Chemical Pathology—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 23)

Lecturer, Senior Lecturer or Associate Professor in Applied Genetics at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 23)

Senior Lecturer (preferably with research experience in the field of neurohistology) in Physiology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 24)

Chair of Botany—The Secretary, The Queen's University, Belfast (October 31)

Chair of Inorganic and Physical Chemistry in the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 31)

Demonstrators in Biochemistry, Animal or Plant Physiology, Soils, Parasitology, Livestock Anatomy and Histology, Nutrition, Agronomy, Livestock Husbandry, and Physiology— The Registrar, University of New England, Armidale, N S W , Australia (October 31)

Senior Research Fellow or Research Fellow in the Department of Theoretical Physics, Research School of Physical Sciences, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, November 2)

Lecturer (with qualifications in either pure or applied mathematics) in Mathematics at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (New Zealand, November 30)

Assistant or Associate Professor of Pathology at Queen's University, Kingston, Canada—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1

Lecturer in Mathematics—The Secretary, Royal College of Science and Technology, Glasgow

Research Assistants (graduates) in Electrical Engineering, for work in the fields of transistor applications or the properties of dielectric materials—Head of the Electrical Engineering Department, Northampton College of Advanced Technology, St John Street, London, E C 1

Research Assistants (2) in Physics, one for theoretical and/or experimental work connected with the theory of liquids, and the other for meteorological or solid state physics—The Secretary, Sir John Cass College, Jewry Street, London, E C 2

Senior Technical Officer (with a degree or diploma in agriculture or agricultural botany) in the Cereals Section of the Seed Production Branch—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Committee of the Privy Council for Agricultural Research Report of the Agricultural Research Council for the year 1957–1958 Pp vii+173 (Cmnd 750) (London H M Stationery Office, 1959) 8*s* net [96

Report of a Conference on Herbage Seed Production organized by the N I A B in conjunction with the British Seeds Council, Cambridge Guildhall, 18th and 19th November, 1958 Pp 481–576 (Preprint from the *Journal of the National Institute of Agricultural Botany*, Vol 8, No 3, 1959) Farmers Leaflet No 3 Varieties of Potatoes Pp 6 (Cambridge National Institute of Agricultural Botany, 1959) [96

Sir John Cass College Prospectus, Session 1959–60 Pp 55 (London Sir John Cass College, 1959) [96

Gas Greets the Future Pp 4 (London The Gas Council, 1959) [96

Department of Scientific and Industrial Research Research for Industry 1958 a Report on Work done by the Industrial Research Associations in the Government Scheme Pp iv+135 (London H M Stationery Office, 1959) 7*s* 6*d* net [96

Council for the Preservation of Rural England Sheffield and Peak District Branch Annual Report, May 1959 Pp 28 (Sheffield Council for the Preservation of Rural England, Sheffield and Peak District Branch, 1959) [96

The Hannah Dairy Research Institute Report for the three years ended 31st March 1959 Pp 52+12 plates (Kirkhill, Ayr Hannah Dairy Research Institute, 1959) [96

University of Nottingham Report of the School of Agriculture, 1958 Pp 68 (Sutton Bonington University of Nottingham School of Agriculture, 1959) [96

British Museum (Natural History) The Succession of Life Through Geological Time By Kenneth P Oakley and Helen M Muir-Wood Fourth and revised edition Pp vii+94 5*s* Fossil Mammals of Africa No 16 The Fore-Limb Skeleton and Associated Remains of *Proconsul africanus* By J R Napier and P R Davis Pp vii+77+10 plates 35*s* (London British Museum (Natural History), 1959) [96

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Educational Publications, Ltd Filmstrip No CX6261 (Botany) Weeds of Cultivated Land 30 frames (colour) 27*s* 6*d* Notes for use with Filmstrip No CX6261 Pp 11 (East Ardsley, Wakefield Educational Productions, Ltd , 1959) [96

Empire Cotton Growing Corporation Annual Report for the year ending 31st March, 1959 Pp ii+22 (London Empire Cotton Growing Corporation, 1959) [106

Institute of Seaweed Research Annual Report for 1958 Pp 23 (Inveresk, Midlothian Institute of Seaweed Research, 1959) [106

Help for the Arts a Report to the Calouste Gulbenkian Foundation Pp 64 (London Calouste Gulbenkian Foundation, United Kingdom and British Commonwealth Branch, 1959) 3*s* [106

Institution of Gas Engineers Publication No 542 Research Programme of the French Gas Industry within the Framework of the Industry's Technical Development By R Delsol and A Renauldon Pp 20 Publication No 544 Reorganization of the Hong Kong and China Gas Company, Ltd By T Spikins Pp 37 Publication No 545 The Use of Propane/Butane for Gas Making in Vertical Retorts By N V Steenstrup Pp 9 Publication No 549 Coke Preparation and the Solid-Fuel Market By J B Grey and R J Newman Pp 36 (London Institution of Gas Engineers, 1959) [106

Government of Northern Ireland Ministry of Agriculture Leaflet No 34 The Pruning of Apple Trees Pp 7+7 plates Leaflet No 35 The Feeding of Bacon Pigs Pp 9 Leaflet No 37 Turkey Production Pp 13 Leaflet No 62 Tree Planting and Timber Production on the Farm Pp 12 Leaflet No 73 Potatoes Pp 26 Leaflet No 124 Weed Control in Agriculture Pp 20 (Belfast Ministry of Agriculture, 1959) [186

The Two Cultures and the Scientific Revolution By Sir Charles P Snow (The Rede Lecture 1959) Pp iv+52 (Cambridge At the University Press, 1959) 3*s* 6*d* net [186

Forestry Commission Report on Forest Research for the year ended March, 1958 Pp viii+191+5 plates (London H M Stationery Office, 1959) 9*s* 6*d* net [186

Central Youth Employment Executive Choice of Careers No 62 The Pharmacist Second edition Pp 20 (London H M Stationery Office, 1959) 9*d* net [186

Birmingham Natural History and Philosophical Society The Records of the Society and the Story They Tell By K L Kenrick (Centenary Celebrations 1958) Pp 52 (Birmingham Birmingham Natural History and Philosophical Society, 1959) [186

Annual Report on the Progress of Rubber Technology, Vol 22, 1959 Pp ix+125+xii (Cambridge W Heffer and Sons, Ltd , 1959 Published for the Institution of the Rubber Industry, 1959) 25*s* [186

National Institute of Industrial Psychology Report 14 Tests for Engineering Apprentices—a Validation Study By C B Frisby, D F Vincent and Ruth Lancashire Pp ii+24 (London National Institute of Industrial Psychology, 1959) 5*s* [186

Building Research Station Digest No 122 Wind Effects on Roofs Pp 8 (London H M Stationery Office, 1959) 4*d* [186

National Union of Students 1959 Grants Year Book Local Education Authority Awards to Students Pp 107 (London National Union of Students, 1959) 2*s* 6*d* [186

Department of Scientific and Industrial Research Food Investigation The Torry Research Station and the Humber Laboratory a Brief Explanation of Their Work Pp 16 (London Department of Scientific and Industrial Research, 1959) [186

After Work Leisure and Learning in Two Towns (Studies made in Bolton and Rochdale for the Manchester and District Advisory Council for Further Education) Pp 63 (London National Institute of Adult Education, 1959) 3*s* 6*d* [186

Department of Scientific and Industrial Research Radio Research Special Report No 28 The Conversion of Ionospheric Virtual Height-Frequency Curves to Electron Density-Height Profiles By Dr J O Thomas and M D Vickers Pp v+48 (London H M Stationery Office 1959) 3*s* 6*d* net [186

B B C Engineering Monograph No 25 A Quality-Checking Receiver for V H F F M Sound Broadcasting By C G Mayo and R E Jones Pp 15 (London British Broadcasting Corporation, 1959) 5*s* [186

Russian Journal of Inorganic Chemistry, Vol 4, No 1 (January 1959) In English translation Pp iii+105 Published monthly Subscription rates Ordinary rate £30 (U S A 90 dollars) Rate for Libraries of Universities and Technical Colleges £22 10*s* (U S A 67 50 dollars) (Single copies £4 (U S A 12 dollars) (London The Chemical Society, 1959 Distributed by Cleaver-Hume Press, Ltd) [186

Other Countries

United States Department of the Interior Geological Survey Professional Paper 272–B The Effect of the Additions of Heat from a Powerplant on the Thermal Structure and Evaporation of Lake Colorado City, Texas By G Earl Harbeck, Jr , G E Koberg and G H Hughes Pp 51+2 plates 50 cents Professional Paper 294–K The Rocks and Fossils of Glacier National Park The Story of Their Origin and History By C P Ross and Richard Rezak Pp iii+401–439+plates 51–53 Professional Paper 299 Geology of the Arkansas Bauxite Region By Mackenzie Gordon, Jr , J I Tracey, Jr , and M W Ellis Pp viii+268+39 plates (Washington, D C Government Printing Office, 1959) [46

East Africa High Commission East African Fisheries Research Organization Annual Report, 1958 Pp ii+48 (Jinja East African Fisheries Research Organization, 1959) [96

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Union of South Africa Department of Commerce and Industries Investigational Report No 36 The South African Pilchard (*Sardinops ocellata*) and Maasbanker (*Trachurus trachurus*) The Chætognatha Off the West Coast of the Union of South Africa, July 1954–June 1955 By A E F Heydorn (Reprint from *Commerce and Industry*) [Pp 56 (Pretoria Government Printer, 1959) [96

Conseil Permanent International pour l'Exploration de la Mer, Charlottenlund Slot, Danemark Rapport et Procès-Verbaux des Réunions, Vol 146 1^{ere} Partie Procès Verbaux, Septembre–Octobre, 1958 2eme Partie Rapport Administratif, 1957 Pp 51 (Copenhague Andr Fred Høst & Fils, 1959) Kr 15 00 [96

Université de Paris Laboratoire Arago, Banyuls-sur-Mer Faune Terrestre et d'eau Douce des Pyrénées-Orientales Fascicule 1 Hyménoptères Vespiformes des Environs de Banyuls-sur-Mer Par H Nouvel et H Ribaut Pp 32 Fascicule 2 Aphidoidea Par G Remaudière Pp 66 Fascicule 3 Névroptéroides Par Jacques Auber Pp 42 Faune Marine des Pyrénées-Orientales Fascicule 1 Céphalopodes Par Katharina Wirz Copépodes, Isopodes et Helminthes Parasites de Céphalopodes de la Méditérrainée et de l'Atlantique Européen Par R Ph Dollufs Pp 72 Fascicule 2 Echinodermes Par G Cherbonnier Pp 67 Fascicule 3 Opisthobranches Par K Wirz-Mangold et U Wyss Pp 71 (Paris Hermann et Cie , 1958) [96

Reflections of a Mathematician By Prof L J Mordell Pp vii+50 (Montreal Canadian Mathematical Congress, Chemistry Building, McGill University or Ecole Polytéchnique, 2500 Guyard Avenue 1959) [96

Canada Department of Mines and Technical Surveys Geological Survey of Canada Bulletin 47 Revision of the Hazelton and Takla Groups of Central British Columbia By H W Tipper Pp vii+51 (Ottawa Queen's Printer, 1959) 75 cents [96

Seventh Annual Report, July, 1957–June 1958 of the Netherlands'–Norwegian Joint Establishment for Nuclear Energy Research Pp 32 (Kjeller, near Lillestrøm Netherlands'–Norwegian Joint Establishment for Nuclear Energy Research, 1959) [96

Companhia de Diamantes de Angola (Diamang) Servicos Culturais Museu do Dundo Publicacoes Culturais No 41 Subsidios para 1 Estudo da Biologia na Lunda Estudos Diversos (16) Lamiinæ (Coleoptera, Cerambycidæ) de l'Angola Par S Breuning Coléoptères Cérambycides d'Angola (Prioninæ et Cerambycinæ) Par A Villiers Eine neue Diplonevra–Art aus Angola (Dipt Phoridæ) Von Erwin Beyer Révision des expéces Africaines de la Famille Fulgoridæ (Super-famille Fulgoroides—sous ordre des Homoptères) Par Dr V Lallemand Segunda contribuicao para 1 Estudo dos Estrepsipteros Angolenses (Insects Strepsiptera) Por Ed Luna de Carvalho Pp 154. (Lisboa Companhia de Diamantes de Angola, 1959) [96

New Zealand Department of Scientific and Industrial Research Geophysics Division Amberley Observatory—Magnetic Results for 1955 Pp ii+62 (Wellington Government Printer, 1958) [186

American Journal of Science Radiocarbon Supplement, Vol 1, 1959 Edited by Richard Foster Flint and Edward S Deevey, Jr Published annually Subscription rate 4 50 dollars a year (Vol 1 will be sold for 2 50 dollars until 1 January 1960) (New Haven, Conn Sterling Tower, Yale University, 1959) [186

United States Atomic Energy Commission Indemnification of Atomic Energy Activities and Operations of Advisory Committee on Reactor Safeguards, 1958–1959 Report to the Joint Committee on Atomic Energy on Operations under Section 170 of the Atomic Energy Act of 1954 as Amended Pp iii+74 (Washington, D C United States Atomic Energy Commission, 1959) [186

Boletim do Museu Nacional, Rio de Janeiro, Brasil Nova Series No 189 (Zoologia) Fauna do Distrito Federal 48 Contribuicao para a Estudo dos Longicorneos do Rio de Janeiro (Coleoptera-Cerambycidae) By D Zajciw Pp 26 No 190 (Zoologia) Contribuicao ao Estudo da Familia *Arctiidae* 6 *Mellamastus* Gen Nov para *Amastus* Nero Weym , 1907 (Lepidoptera, Heterocera) By Alfredo Rei do Rego-Barros Pp 14 No 191 (Zoologia) Descricao de duas Especies Novas de *Panchlora* Burm , 1838 e Catalogo das Especies (Blattidae-Panchlorinae) By Isolda Rocha e Silva Albuquerque Pp 21 No 192 (Zoologia) Contribucao ao Estudo da Familia *Arctiidae* 7 Novo Genero e Nova Especie de *Arctiidae* de Sao Paulo (Lepidoptera, Heterocera) By Alfredo Reo do Rego-Barros Pp 7 No 193 (Zoologia) Novas Especies de *Coenosiinae* (Diptera-Muscidae) By Dalcy de Oliveira Albuquerque Pp 17 No 194 (Zoologia) Contribuicao ao Conhecimento de *Hylemyoides* Albuquerque, 1949, com Descricao de duas Especies Novas (Diptera-Muscidae) By Dalcy de O Albuquerque Pp 12 No 195 (Zoologia) Tipos de *Saturnioidea* no United States National Museum 13 Genero *Adelowalkeria* Travassos, 1941 (Lepidoptera, Adelocephalinae) By José Oiticica-Filho Pp 15 (Rio de Janeiro Museu Nacional, 1958 and 1959) [186

Food and Agriculture Organization of the United Nations Indo-Pacific Fisheries Council Proceedings—7th Session, Bandung, Indonesia, 13–27 May 1957 (Sections II and III) Pp iv+218 (Bangkok IPFC Secretariat, FAO Regional Office for Asia and the Far East, 1958) [186

U S Department of Commerce Coast and Geodetic Survey Publication 62-1 Tellurometer Manual By Austin C Poling Pp v+66 (Washington, D C Government Printing Office, 1959) 40 cents [186

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NUCLEAR POWER AND ITS DEVELOPMENT

SIR JOHN COCKCROFT is reported to have expressed the opinion on April 26 that in 1966 some 25 per cent of the requirements of the United Kingdom for electricity would be met by nuclear generation, 50 per cent by 1975 and 100 per cent by the end of the century. Questions asked in the House of Commons on June 8 indicate a disposition to allow political and social considerations to over-ride, if not distort, the technical and economic aspects, and there have been other attempts to make the effect on the coal industry the deciding factor in determining the development of nuclear power. The implications of technological change have been ignored, as has the effect of development on the cost of electricity supplied by nuclear power-stations, which Sir Christopher Hinton stressed very strongly in his Axel Axson Johnson Lecture delivered at Stockholm on March 15, 1957.

In his reply on behalf of the Government, the Paymaster-General was emphatic that the programme for the development of nuclear energy in Britain over the next few years was arranged after careful consideration, and it certainly could not be upset on any temporary considerations. An admirable broadsheet, "Prospects for Nuclear Power" (No. 431, March 1959), issued by Political and Economic Planning, is well designed to remove misunderstandings and facilitate an objective approach to this problem, in which it is extremely difficult to separate at all sharply the technical and economic from the political and social elements. Although the broadsheet is particularly concerned with the world position and Britain's export prospects, it includes a lucid discussion of the impact of nuclear power which deserves to be widely read. The brief paragraph on the position in the United Kingdom points out that by 1966, when the dozen or so nuclear power-stations required to supply the target capacity of 5,000–6,000 MW. are in operation, the cost of the electricity generated should be almost competitive with that from other types of power-stations wherever sited; this answers the criticism implied in the questions in the House of Commons.

The broadsheet points out that by 1966 the nuclear power-stations will be supplying a quarter of the electricity used in Britain and doing the work of 18 million tons of coal a year, and that it is estimated that the cost of generating electricity from the largest of the stations now under construction, that at Hinkley Point, will be between 0·59*d*. and 0·66*d*. per kWh., compared with 0·53–0·64*d*. for an up-to-date coal-fired plant. The cost of electricity from the largest station now being built is competitive with that from a high-efficiency coal-fired station built on the same site. Moreover, for the later stages of the present programme, when all new generating plant may be nuclear, Britain is considering types of reactor that will be cheaper to build and more efficient to operate, as well as able to accept re-cycled plutonium to replenish the burnt fuels, and these types should produce electricity more cheaply than conventional plants. Two such reactors are the gas-cooled heavy-water moderated reactor, and the advanced gas-cooled reactor: an experimental version of the latter is already being built at Windscale.

These facts, which were essentially given by Sir Ian Horobin in moving the second reading of the Electricity (Borrowing Powers) Bill on January 20, sufficiently display the tendentious character of the question to which Sir Ian replied in Parliament on June 8. It should also be remembered that the high-temperature gas-cooled reactor is to be studied at Winfrith Heath, and the sodium-cooled fast-breeder reactor at Dounreay, both with the subsequent period in mind when reactors will be needed to take over an increasing proportion of the base load. From the Dounreay reactor, to be in operation this year, will come the data necessary to enable fast reactors using plutonium fuel to be integrated with existing thermal reactors. This will improve the burn-up of natural uranium to somewhere near the theoretical limit. The reactor programme is also supported by large facilities for research and an extensive research programme, while production and fuel-processing facilities are also well developed in Britain, and capacities are sufficient to meet the needs of other countries. Lord Mills, the Minister of Power, stated explicitly in the House of Lords on March 3 that the nuclear-power programme for 1964 onwards had not yet been determined.

This position, however, needs to be set against the general background outlined in the PEP broadsheet, which stresses, too, the dynamic nature of the energy position, both nationally and internationally, and the way in which non-economic influences often determine the most economical way of meeting demands for energy. The great promise of nuclear energy is that, with ample resources of uranium and thorium, and the high energy content of each ton of raw material which makes transport a negligible factor, it will eventually provide all nations with an unlimited and virtually indigenous supply of energy at an economic cost. Although this lies well into the future, nuclear energy should make an immediate though modest contribution, particularly in Europe.

The factors which limit this contribution must be carefully noted in an objective assessment of the situation. First, for technical reasons, nuclear fission reactors are only efficient when employed in large units. The large amounts of electricity produced from each nuclear power-station can in the near future be generated at an economic cost only if they can be used to the maximum. This is only possible where electricity systems are fully developed in a grid-network such as an industrial area provides

Accordingly, nuclear energy is as yet unlikely to help under-developed countries, nor will it be suitable for some time for the direct production of heat where small units are normal In Europe, where fossil fuels are expensive, nuclear energy should be competitive within the next ten years for what is called base-load operation, that is, power-stations operating virtually all around the clock feeding electricity into the grid

The second factor is that small coal is particularly suitable for power-stations, and the proportion of small-coal production is continually growing as more coal is mined by mechanical methods This coal can only be burnt efficiently in very large plants and its use is thus almost confined to power-stations Criticism of Britain's nuclear-power programme arises largely from this fact that nuclear energy is suitable for the production of electricity only in the conditions to which the growing quantity of small coal is also suited

The third factor is that production of electricity at a price competitive with conventional power only means an additional supply of electricity and not the introduction of a cheap new fuel Electricity has its own particular advantages, and its use in Britain is continually growing , but it is not, at present costs, an economic substitute for other sources of energy for many purposes The nuclear-power programme should enable those needs to be met more easily, but it will not obviate the need for other fuels for these purposes Nevertheless, the development of nuclear energy holds great promise, and Britain's prompt start has given her an early lead in tackling the vast technical problems involved, and only the U S S R and the United States have programmes at all comparable in size to the British Moreover, the British power programme, based on the gas-cooled natural-uranium reactor, is the only large-scale programme which is being carried out in a Western country, and the British type of reactor has been proved in operation, having supplied electricity to the grid for some two years

Nevertheless, the survey in *Planning* of the prospects for British exports of nuclear power-stations and related fuel and equipment leads to the conclusions that the prospects for British firms to export reactors are not so bright as they were once thought to be Nuclear power is indeed regarded as the most helpful long-term solution of the fuel problem in many European countries, and the principal countries are in a position to exploit nuclear power without too much difficulty They possess the necessary scientific and technical skills and the capacity to build equipment, and they will therefore want to develop their own nuclear industry as fast as they can They may buy one or two reactors from other countries, as Italy has done, in order to gain experience of operation and construction ; but after that they will probably do more and more of the work themselves They are unlikely to set up their own fuel-processing plant, partly because of expense and partly because most European countries have no uranium deposits and are unlikely to obtain uranium without some control against the production of plutonium France is the one country of Europe which will have a self-contained nuclear industry

In the Scandinavian countries, and possibly in Spain and Portugal, competition is likely to be fierce, and although the Calder Hall power-station has impressed potential customers with the merits of the British type of reactor, steady and impressive publicity is required Outside Europe, the first markets —for the next ten years at least—will be in Japan and India, but China is likely to be tied to Russian developments at first Several countries in Latin America might prove customers for the British type of large power-station reactor

Whether British or American power reactors are bought—and these are the only countries at present offering to sell power reactors and supporting the offer with a fuel service—the PEP broadsheet suggests that the future of the nuclear reactor export market is closely tied to a successful small reactor A cheap small reactor similar to that for moderately powered gas-turbine and diesel-powered generating sets could transform areas which are now under-developed Here, since British efforts have been concentrated on the Calder Hall type, Britain is less favourably placed than the United States to design reactors for special conditions Without the urgency of Britain's fuel problems, the United States has been able to experiment with a wide variety of types of reactor, and this could prove an important advantage in meeting the future export demand for a small and flexible reactor system Besides this, the United States is at present the only country that can supply enriched uranium for reactors abroad

Britain is now taking the preliminary steps to enable her to meet the demand for small reactors, but it is possible that the Soviet Union, although it has not yet been active in export competition, could also have an advantage over Britain in the matter of reactor types Nevertheless, the broadsheet points out, reactors are not the only product that can be exported The one part of the British power-reactor which is not manufactured by industry is the fuel element The rest, including ancillary equipment, such as turbines, generators, handling gear, processing equipment and control instruments, are all the products of industrial firms Lord Mills, it is true, has directed attention to the more limited opportunities in the near future for new consortia of firms with design teams trained by the Atomic Energy Authority and which would be capable of tendering for the construction of complete nuclear power-stations , but at the same time, he emphasized the opportunities for the manufacture of small reactors, including research reactors.

Nuclear energy, as the PEP broadsheet puts it, means that there will be an increased demand for those products which British firms can supply as cheaply as any of their competitors , but the prospects for British exports of nuclear reactors and equipment are not determined solely by the competitive ability of British firms One dominant factor will be the political agreements that the Government is able to make. Marketing nuclear reactors is not purely a commercial undertaking, for, as the broadsheet duly notes, international politics are involved, and unless this is clearly understood British chances of building up an export trade will be small.

For this reason alone, it is important that Britain should establish close and satisfactory relations both with the International Atomic Energy Agency and the European Organization for Nuclear Research, and also with Euratom—the European Atomic Energy Community and its six members. A second factor, however, to which *Planning* does not direct attention is that of scientific and technical man-power. Although in the stricter sense this lies outside the scope of the broadsheet, it is probably the ultimate factor on which the prospects for British development of nuclear energy depend. Unless the resources of scientific and technical man-power in Britain are fully developed and effectively used, Britain is unlikely to be able to seize the opportunities that nuclear energy will bring—even to secure all the advantages which its development in Britain might offer to the economy of the country—still less to hold her own in the keen competition forecast in this broadsheet. Nor is this simply a matter of training sufficient scientists and technologists: it is also a matter of seeing that they are wisely used, that our organization and administration of research are adequate and in balance, and that the administrators and statesmen called upon to handle the complex and interlocked technical, economic and social problems which the development of nuclear power will bring are competent to give due weight to all the scientific and technical issues, no less than to the economic or political aspects of the situation.

For some months Euratom experts have been drafting a new and realistic programme for the six member countries, taking account of changing oil and coal prices. Since the PEP broadsheet was issued, the report on this programme has been finished, but owing to disagreement at the top it has been withdrawn and is not to be published. This disagreement has jettisoned Euratom's plans for all but the 1,000-megawatt programme being carried out with American aid, and it is obvious from the broadsheet that most of the chances open to British industry of tendering for foreign nuclear power-stations have likewise disappeared.

Sir Ian Horobin took a far more confident view in replying in an adjournment debate on the nuclear power programme in Britain in the House of Commons on July 1. He confirmed that latest figures gave the cost of electricity from conventional stations as 0·5–0·65*d*. a unit compared with 0·65–0·7*d*. for electricity from nuclear power-stations; but he emphasized that the statement that nuclear energy to-day is 40 per cent more expensive than conventional power was based on a comparison of the cheapest possible coal and the dearest existing nuclear energy. Sir Ian suggested that the real difference is probably more like 15–20 per cent, and he pointed out that in view of the 70 per cent rise in the price of coal over the past ten years it would have been unrealistic to base policy on the assumption that coal would not be 5–7*s*. a ton dearer than it is now. He also thought that the price of uranium will fall when the present contracts expire and that this factor, with a further slight rise in the price of coal, is likely to decrease the margin of 15–17 per cent against nuclear energy, and that the price of generating electricity by nuclear energy is likely to touch that of generating by coal in the late 'sixties.

Sir Ian Horobin insisted that the British nuclear-power programme is a very carefully considered whole, and that it is probable that what may be called the Calder Hall type of reactor has several years of valuable development before it. About 1961 the advanced gas-cooled reactor should become critical, and if this is successful the first commercial type may be in operation about 1965. The work done with the fast breeder reactor now being developed at Dounreay has been very successful and a period of low-power testing at Dounreay is expected to begin this summer. If all goes well, we may hope to have this type in operation by about 1970, and its low capital cost and its place in the balanced programme offer exciting possibilities, particularly in flexibility. By that time a substantial number of stations of the Calder Hall type would be in operation, all producing plutonium. We must bear in mind, Sir Ian said, the possibility of a situation arising when it would be possible to build very much larger stations than originally conceived and that perhaps only about half a dozen more stations would come into the programme. He repeated that we cannot afford to run any risk of completely unbalancing the structure of the industry in Britain by interfering with the present programme. When that programme is complete, further decisions will be required, and although preliminary consideration is being given by the Government to the subject, it is not thought that it is necessary to decide for a further year or two what stations should be built after 1965. It is very important, he said, that everyone should realize that a nuclear-power programme on the scale of that in Great Britain must be a long-term, carefully balanced programme and that it cannot be interrupted in response to short-term considerations. Britain is now the major civil nuclear Power, and the need for thought and care in investment and design are correspondingly great.

DARWIN WITHOUT MODERN SCIENCE

Darwin and the Darwinian Revolution

By Dr. Gertrude Himmelfarb. Pp. ix+422. (London: Chatto and Windus, Ltd., 1959.) 42*s*. net.

An adequate study of Darwin, his scientific achievements, and the result of his work in all the fields of human endeavour which they have affected makes rigorous demands on the competence of whoever attempts to write such a book. Dr. Himmelfarb brings to her task a concentration of interest and of effort, the former of which is passed on to the reader by the sustained vigour and elegance of her style and the skill with which the book is constructed, while the mastery of her technique hides the laboriousness of the work involved.

She has read practically everything there is to read by Darwin and on Darwin, including manuscripts hitherto unpublished, and has subjected the material to lucid analysis in terms of the history of Darwin's life, experiences, contacts with other persons, researches, results, doubts and beliefs. He is situated in his intellectual environment, his home life, his ailments real or imagined, and his place in history. The social, scientific, religious, political and general public climates of his day are vividly portrayed, and there can seldom have been a work of biography undertaken with such bibliographical care.

But while it would be difficult to exaggerate the excellence of this book as a contribution to the history of the events, ideas and arguments as a result of which Darwin produced his theory of evolution by natural selection, the case is altered when it comes to the evaluation of this theory in terms of the present state of scientific knowledge, because Dr. Himmelfarb's work is imbued with a relentless aversion to natural selection, pursued by means of a skilful and acute dialectic without reference or regard to the results of scientific research during the past fifty years. Indeed, this is directly implied by the statement (p. 366) that "the present status of Darwinism has not altered much since 1860, when Huxley pronounced it to be not an established theory but a tentative hypothesis". When she tries (p. 368) to substantiate such a view to-day by quoting William Bateson, she gives herself away at once.

That the author is not familiar with, or prefers to ignore, the growing edge of scientific knowledge by observation and experiment during the past fifty years appears from statements such as the following (p. 269): "In the experiments of Mendel and de Vries, new species appeared suddenly in the form of mutations". Mendel neither claimed nor obtained any such results. On the contrary, his genius lay in selecting for his experimental material strains which differed only in one or two characters: differences immeasurably inferior to those of specific rank. As for de Vries's 'mutations', it has long been recognized, thanks primarily to the work of T. H. Morgan and his colleagues A. H. Sturtevant, C. Bridges and H. J. Muller, that they are not mutations at all, but the results of a rare method of 'sporting' by permanently heterozygous strains technically known as the 'crossing-over of balanced lethals'.

When the author attributes to neo-Darwinians the statement (p. 270) that "only the smallest mutations could be favourable and that such favourable mutations were in fact so rare a phenomenon that without natural selection not even a fruit-fly, let alone a man, could have developed", and concludes, "Thus it became the very paucity of variations, the very improbability of their concurrence, that was now made to tell in favour of natural selection", she makes the elementary and very outdated mistake of thinking that mutation is the only supply of variation. It has long been known that recombination of genes is enormously greater as a source of supply of variation than mutation itself, and it produces gradual change.

Dr. Himmelfarb has not grasped the fundamental significance of the work of Sir Ronald Fisher, whom she calls "the mathematician". He showed, first, that natural selection of genes within the gene-complex is a universal phenomenon, which explains why the genes gradually *become* either dominant or recessive. This is how evolution proceeds. Mendelian genetics itself provides evidence of Darwinian selection. He showed, secondly, that selection is so much more powerful than mutation, that no mutation can have the remotest chance of becoming a normal component of a population if there is the slightest degree of adverse selection exerted against it. He showed, thirdly, that as all organisms are tolerably well adapted to the conditions under which they live in their present environment, the vast majority of mutations are bound to be deleterious to the organisms in the conditions under which they arise, and this proves that any attempt to explain evolution by an appeal to causes which might be supposed to impart favourable qualities or directions to mutations through 'inner feelings', '*élan vital*', 'urges', or the transmission of somatic modifications, is killed stone dead at the start. "Every theory of evolution which assumes, as do all the theories alternative to natural selection, that evolutionary changes can be explained by some hypothetical agency capable of controlling the nature of mutations which occur, is involving a cause which demonstrably would not work even if it were known to exist." The fact that wild species in Nature are highly heterozygous shows that mutant genes, subjected to adverse selection when they first arose, remain as recessives in the gene-pool, and function as a reserve which is drawn on when environmental conditions change, and some of these genes then become dominant by selection in the gene-complex, and established in the population. It can also be shown that selection is exerted in favour of the heterozygous state *per se*.

Results such as these should find a place in any modern appraisal of the position of natural selection at the present stage of knowledge; but Dr. Himmelfarb has preferred to say (p. 276) that "Posing as a massive deduction from the evidence, it (natural selection) ends up as an ingenious argument from ignorance". The word "ignorance" is a double-edged weapon when it is used by an author without any indication of awareness of the experimental results obtained by such distinguished scientists as E. B. Ford, C. D. Darlington, P. M. Sheppard, A. J. Cain, W. H. Dowdeswell, H. B. D. Kettlewell or C. H. Waddington, to mention only those working in Great Britain.

The intercalation of quotations from Darwin, labouring in his unavoidable ignorance of the principles of Mendelian genetics, to disparage arguments which have since been substantiated by the results of modern experimentation in natural selection is regrettable. When Darwin wrote a hundred years ago that "we are far too ignorant, in almost every case, to be enabled to assert that any part or organ is so unimportant for the welfare of a species that modification in its structure could not have been slowly accumulated by natural selection", he was quite correct, and it was merely tendentious for Dr. Himmelfarb to say (p. 276) that "three negatives do not normally constitute a positive". When Darwin went on to say that "it would be extremely bold to maintain that no serviceable transitions are possible by which these (electric) organs might have been gradually developed", he was prophetic, as Dr. Lissman's researches have since proved. The initial stages in the evolution of flight in birds, colour-vision, or the whale's adaptation for avoiding caisson-disease, to mention only a few additional striking cases, have all been shown to be capable of conferring survival value from the inception of the improvement

The statement (p 277) that "The eye is obviously of no use at all except in its final, complete form" completely ignores the comparative anatomy, embryology and physiology of the lower chordates, which show how light-sensitive cells in the epidermis have been brought into place, from the surface of the skin into the neural tube and then into the retinal layer of the eye-cup, and are functional at each stage Dr Himmelfarb (p 279) accuses Darwin of invoking the *perfection* of the eye at the same time as he quoted Helmholtz on the inadequacy and imperfection of the eye, but in the "Origin of Species" (World's Classics edition, p 190), Darwin wrote, "its marvellous yet not absolutely perfect characters" What Darwin claimed was that natural selection confers *improvement*, and in the case of the vertebrate eye this is undeniable to anybody familiar with the visual organs in *Amphioxus*

The statement that "the persistence without change of any forms over a long period of time is difficult to explain by natural selection" is particularly unfortunate, because so long ago as 1878 T H Huxley pointed out that natural selection is the only mechanism that can account both for change and for stability, and as recently as 1952 E B Ford supplied the genetic explanation of this by showing that the non-contamination of genes and the rarity of mutation produced stability, while the power of recombination of genes can produce endless variability, under the control of natural selection in each case

"How can selection, knowing nothing of the end or final process, function when the only test is precisely that end or purpose?" asks Dr Himmelfarb (p 277) The experimental results of investigations on the evolution of industrial melanism in moths show how the selective taking by predators of prey ill-adapted to their environment can be seen going on, and the intensity of the selection pressure can be measured with mathematical precision, mimetic resemblances in butterflies are improved and confer survival value in mathematical relation to the prevalence of distasteful models, the method of capture, marking, release and recapture enables the predations by thrushes on snails of different colours to be correlated with the seasonal variation of vegetation, and the longevity of different genetic types of moths to be measured in terms of concrete units of time That is how selection actually operates

Astonishingly out of date is the statement (p 284) that "the entire discussion of sexual selection is anthropomorphic in its basic conception, for whether the coloration of a bird is judged to be either beautiful or monstrous, it is by human standards that the judgment is made" It is now quite clear that the 'beautiful' *and* 'monstrous' colours in question, to which must be added structures, attitudes, and behaviour-patterns used in courtship, function, as Sir Julian Huxley, N Tinbergen and many others have proved, as stimuli by which a threshold physiological condition in the partner is reached and a release mechanism set in motion There is no question of any anthropomorphic æsthetic choice

It is quite correct that many of the examples which Darwin thought conformed to the principle of sexual selection have since been found to owe their origin to other than epigamic causes, such as warning marks, recognitional or threatening defensive characters But some characters, as those of the male peacock, ruff, or argus pheasant, are good examples of the sexual selection in Darwin's sense, as Sir Julian Huxley showed more than twenty years ago, yet Dr Himmelfarb concludes (p 300) that "Sexual selection has all the faults of natural selection and more: the suspicious facility with which it can be made to explain anything and everything, the manipulation of evidence for whatever purposes are convenient, and the invocation of ignorance when all else fails" Here, again, the historical present tense is used, but there is nothing to show that the author does not intend it to apply to the present and that the remarks made represent the actual state of scientific knowledge

Turning now to another discipline of science, we find Dr Himmelfarb stating (p 271) that, "Geology, however, has been notably unforthcoming, and instead of being the chief support of Darwin's theory, it is one of its most serious weaknesses" It is difficult to believe that such a phrase could have been written in 1959 for 1959 She goes on to say that "It might have been expected that in those cases where the geological record is more or less complete we would find closely graduated varieties of species existing at the beginning and at the close of the period Yet even here we do not find such a graduated series" It can only be concluded that she has not held in her hands the series of ammonites from *Liparoceras* through *Androgynoceras*, *Amaltheus* to *Pleuroceras*, demonstrated by L F Spath, nor the series of *Micraster* demonstrated by D Nichols As for the series of horses, Dr Himmelfarb's information is not more recent than that of T H Huxley in 1870 Actually the fossil series of ancestors of the horse is now so good that George Gaylord Simpson has been able to measure the time required for the conversion of a species into another and the length of life of a species (two million years in horses) T S Westoll had done the same for fish, which evolve at different rates Simpson was also able to show that the geological record in some places is so good that it is now possible to calculate the degree of variability of fossil species and to prove that it is not correlated with their evolution-rate This is further evidence that natural selection, not mutation, controls the rate and direction of evolution

The statement that the geological record is one of the most serious weaknesses of Darwin's theory is ridiculous Even in his day, the Mesozoic mammals of the Stonesfield Slate had been discovered, and that most beautiful of all known fossils, *Archaeopteryx*, was known, showing such a perfect transition between the reptilian and the avian stages of that line of evolution that it can be regarded as ancestral to all later birds It also demonstrates the way in which one vertebrate class become converted into another, by piecemeal transformation of bits of the body one by one, a process called mosaic evolution Other examples of representatives of precursors are *Jamoytius* between the lowest chordates and the fishes, *Ichthyostega* between fishes and amphibia, *Seymouria* between amphibia and reptiles, *Ictidosaurs* between reptiles and mammals, *Australopithecus* between apes and man All these, and countless others, are a striking vindication of Darwin's views

The sudden appearance in the geological record of representatives of important groups (such as the gastropods or vertebrates) is no fly in the ointment of Darwin's theory, and it receives a logical explanation from the obligatory rarity of tentative initial types, and from the principle of 'clandestine evolution' of young stages without hard parts and therefore not preserved as fossils until they became adult in their new state As for the abrupt appearance of fossils in "the lowest fossiliferous strata", the number of fossils discovered in Pre-Cambrian deposits goes on increasing and now includes algae and fungi in which eight amino-acids could still be recognized although they are 1,700,000,000 years old

Dr Himmelfarb states (p 310) that chemists showed that all the pieces of the 'Piltdown find' revealed the same fluorine content This was not the case The earliest estimations by K P Oakley and C R Hoskins showed fluorine percentages varying from 3 1 to less than 0 1, estimations correct to within a range of ± 0 1 This proved that all the 'specimens' were not Lower Pleistocene Subsequent estimations by more refined methods showed that the latest of these were not even Upper Pleistocene But if Dr Himmelfarb really thinks that the exposure of the Piltdown fraud "leaves the theory (of evolution), after a century of search, without the much desired link", *Proconsul, Australopithecus, Pithecanthropus* and Neanderthal man are there to bear witness to what Sir Wilfrid Le Gros Clark has demonstrated from them about the so-called 'much desired link'

If ever the cult of personality should attempt to invade science, it would cease to be science , and if scientists hold Darwin in honour to-day, it is because the evidence, all the evidence, and nothing but the evidence provided by the observations and experiments of biologists who have undertaken research in this field, has shown that the natural selection of mutant and recombined genes is the mechanism whereby the evolution of plants and animals in Nature has been brought about

GAVIN DE BEER

THE FAITH OF A REALIST

Blaise Pascal

The Life and Work of a Realist By Ernest Mortimer Pp 240+4 plates (London Methuen and Co , Ltd , 1959) 21*s* net

MUCH of Pascal's work, and several books about him, are readily available what is not so easy to obtain is an assessment of his place in history in keeping with the pedestal upon which his fellow-countrymen are nearly unanimous in placing him Furthermore, to find an answer to the question as to how much he means to us to-day is assuredly a rewarding task These things the author has done and the result is a notable achievement Pascal emerges as a character of gigantic intellectual and spiritual stature , weak of body, indomitable of will, and relentless in his quest for truth

In the present context, we may perhaps leave aside the well-known facts of his mathematical genius, his contacts with great minds like those of Descartes, Fermat and Desargues, and concentrate upon his theory of knowledge (Chapter 11), which developed from the intense strife going on within him, and which burnt itself out as a consuming fire Pascal was no mere dreamer, but on the contrary passionately concerned with making things work His technical skill, if he were alive to-day, would lift him to the summit of electronic computing, and to the highest triumphs of cybernetics and servo-mechanisms In this sense, he was a realist , his faith transcended it, however, as he reached out towards that greater truth only to be found in charity

It is from some such position as this that we can best approach Mr Mortimer's treatment of Pascal's theory of knowledge, for it is essentially here that the present volume finds much of its *raison d'être* Here too is Pascal's message for the world to-day

The central concept is that of *le cœur* By this Pascal did not envisage something "cardiac rather than cerebral" He uses the phrase to cover a species of synthesis, a type of thought in which analysis gives place to cognition It seems as if this came out of a state of mind akin to despair, in that, for example, the propositions of Euclid needed acceptance of something "given" before any progress could be made, and thus real knowledge could never be obtained In this, he was in effect anticipating Godel s theorem, and the failure of Hilbert to construct a consistent system of mathematics purely mathematically But for Pascal, truth is not apprehended by reason alone, which can only yield statistical properties

Mr Mortimer is at pains to point out that Pascal did not draw this inference himself , it is nevertheless the gist of his whole argument Here indeed is a startling preview of twentieth-century science, quantum theory, operationism and all Nevertheless, the part to be played by *le cœur* remains, and it stands supreme if we are to 'know' the world around us But what is it, if it is not rational knowledge ? Pascal gives his answer—"Le cœur a ses raisons, que la raison ne connait point" Metaphysics may be out of fashion at the moment it looks, however, as if the faith of a great realist may have elevated such a discipline to a position otherwise unheeded

As people exclaimed in another setting altogether, "We have seen strange things to-day" The author has written a book modest in compass but great in concept He has brought Blaise Pascal, his tempests stilled at the last, into the centre of contemporary thought

F I G RAWLINS

ENZYMES—KINETICS AND CHEMISTRY

Behavior of Enzyme Systems

An Analysis of Kinetics and Mechanism By John M Reiner Pp xii+317 (Minneapolis, Minn Burgess Publishing Company, 1959) 6 50 dollars

Proceedings of the International Symposium on Enzyme Chemistry

Tokyo and Kyoto, 1957, organized by the Science Council of Japan under the auspices of the International Union of Biochemistry (I U B Symposium Series, Vol 2) Pp 541 (Tokyo Maruzen, 1958) n p

LET Dr Reiner speak for himself In his foreword addressed to "Timid Souls" he writes, "The foremost purpose of this book, accordingly, is To make it possible for anyone to begin the book knowing substantially nothing, and to finish it an expert for all practical purposes" This is a bold ambition, even when restricted to the field of enzyme kinetics A major adverse criticism of this book is, in the reviewer's opinion, the almost complete lack of reference to published experimental work , one has to turn many pages before one can see even the name of an enzyme and there are virtually no numerical data given Dr Reiner's ideal reader, the ignorant but intelligent man, but one, nevertheless, longing to learn, would find himself bewildered by reality Putting these criticisms aside, this book is a serious piece of scholarship, and provides a useful introduction to the theory of enzyme kinetics

In contrast to Dr Reiner's solo performance, the Proceedings of the International Symposium on Enzyme Chemistry, relating to a conference which took place in Tokyo and Kyoto in October 1957, contains contributions from 228 authors Apart from four special lectures delivered by Profs Chance ("Cytochromes—their Nature and Function in Living Cells"), Engelhardt ("Enzymology and Mechanochemistry of Tissues and Cells"), Lynen ("Phosphatkreislauf und Pasteur-Effekt") and Tamiya ("The Koji, an Important Source of Enzymes in Japan"), the Proceedings are divided into four sections

The first section covers the mechanisms of enzymatic group transfer, the second, enzyme systems of hydrogen, oxygen and electron transport, the third, the formation of proteins and enzymes, and the fourth relates to enzymes and industry (interpreted to include pharmacology) Many of the contributions are, in effect, short reviews (2–10 pages) of specialized topics, supplemented with what was in 1957 new experimental material. These articles are, in general, of a high standard and are, in the main, very readable

The title given to the Conference in no way restricted the range of topics , enzyme chemistry was taken to include any reaction catalysed by enzymes in animals, plants and micro-organisms Papers dealing with the action of thyroxine on isolated animal mitochondria and the role of chlorophyll in photosynthesis occur in the same section

The majority of contributions are in English, a few in German and even fewer in French Almost inevitably some of the papers, from veterans of international conferences, have appeared in substantially the same form before or since

J B Chappell

CHEMISTRY OF PHOSPHORUS

Phosphorus and Its Compounds

By John R Van Wazer Vol 1 Chemistry Pp xiii+954 (New York Interscience Publishers, Inc , London Interscience Publishers, Ltd , 1958) 208*s*

THIS volume must be unique, for it gives in wide scope and considerable detail an account of the structure, the physical and chemical properties, and the chemical reactions of phosphorus and all its main classes of compounds, both inorganic and organic It is also outstanding, not only for the wide range of the modern scientific information which is so clearly presented, but also for the historical background of this information each main topic has a historical introduction, so that, for example, the discussion of the structure of one class of compound may range from a brief review of the theories of a century ago to a more detailed discussion of the most recent evidence supplied by nuclear magnetic resonance spectra

The first two chapters deal respectively with the nuclear and atomic structure of the phosphorus atom, and with interaction between atoms the second chapter discusses in detail bond-energies and lengths, dipole moments, polarity of molecules, ionic radii, etc The following chapters discuss in turn various classes of phosphorus compounds The detailed information available may be assessed from the 380 pages devoted to phosphoric acid and its compounds, divided into five chapters on condensed phosphates, orthophosphoric acid, chain phosphates, ring and branched phosphates and amorphous phosphates, respectively This treatment ranges in these five chapters from the physical and chemical properties of phosphate minerals on one flank to those of the nucleic acids on the other Throughout the book the constant comparison of the properties of the purely inorganic compounds of phosphorus and those of their organic substitution products makes fascinating reading, and may well serve both to widen and to readjust the mental balance with which inorganic and organic chemists have hitherto in their different ways assessed the chemistry of phosphorus

In the preface, the author makes an eloquent plea that the present division of descriptive chemistry into two parts, organic and inorganic, should now be widened to include a third part, namely, phosphorus chemistry Many chemists will shrink from this suggestion, but it must be admitted that although phosphorus chemistry contains, on one hand, a number of reactions which can be regarded as normal reactions of inorganic compounds, and on the other hand many reactions typical of organic compounds, there lies in the centre a host of reactions and aspects of behaviour which are peculiar to phosphorus The same statement might possibly be made of the chemistry of every non-metallic element, but the specific chemistry of phosphorus is, in its range and nature, much greater than that of any other element except carbon This quality is one of the major factors underlying the vast increase in the academic and technical interest in phosphorus chemistry which has occurred during the past twenty years

The price of this book may appear high by English standards, but the volume contains an immense amount of information, liberally illustrated by X-ray structure diagrams, phase-rule diagrams, etc , and by a wealth of valuable tabulated material The final three appendixes list in turn phosphate minerals (40 pages), giving details of each, based largely on Dana's 'System of Mineralogy" , single bond energies and distances with electronegativity differences , and thermodynamic data on the compounds of phosphorus

The book, however, is emphatically not a mere catalogued compilation of facts In spite of the size of the book, the author has maintained to the end a critical treatment of the material under discussion, and this treatment, combined with the author's pleasant and lucid style, gives the book a personal flavour which heightens the reader's interest throughout the volume

The publishers are to be congratulated on the general format and printing of the book, and in particular for printing references at the bottom of pages, where they can be immediately noted by the reader, instead of printing them in a vast huddle at the end of each chapter

The book will be appreciated by all types of chemist, inorganic, organic, physical and phosphoric

F G Mann

Suggestions to Authors of the Reports of the United States Geological Survey

Fifth edition Pp xii+255 (Washington, D C Government Printing Office, 1958) 1 75 dollars

IN the eighty years that have passed since the foundation of the United States Geological Survey, more than 3,500 volumes of scientific and technical literature and more than 20,000 different maps have been published under its auspices—an output far surpassing that of any other geological institution in the world Throughout this long history, continuous efforts have been made to promote lucidity, consistency and uniformity in these publications, and the code of practice established by the Survey for its authors, first published in 1909, has found widespread use outside official circles The much enlarged fifth edition of this manual outlines the successive literary steps which a geologist-author will normally take from the beginning of an investigation to the final proof-reading of his text, maps and illustrations It advises on matters of ethics and professional etiquette, enumerates the requirements of a well-prepared manuscript, deals at length with questions of typographical style, and gives a great deal of detailed information on the form and content appropriate to reports of various kinds More than 50 pages are taken up with sensible advice on composition and expression, forming a sort of "A B C of Plain Words" directed specifically at geologists Not all the suggestions will be acceptable to British readers, who may be somewhat puzzled by the preferred use of 'geologic' and comparable '-ic' endings in a country with a Geological Survey and a Geological Society But there is no similar guide produced on the eastern side of the Atlantic , and, with appropriate warnings, the work could profitably become prescribed reading for all post-graduate students of geology, as a brake on the present over-production of 'geologese'

C. F DAVIDSON

Causes de la Répartition des Etres Vivants

Paléogéographie, Biogéographie Dynamique Par Raymond Furon (Evolution des Sciences, No 10) Pp 168 (Paris Masson et Cie , 1958) 1,000 francs

THIS book is well described by its author, in his preface, as "ce petit livre de 'morceaux choisis' n'est donc dans mon esprit qu'une esquisse de ce que pourrait être un beau livre qui n'existe pas un Traité de Biogéographie", for it touches upon almost every aspect of its subject Unfortunately the touch is too light to permit the suggestion of solutions to the many problems it describes, and this almost inevitably excites, rather than calms, the doubts that haunt most biogeographers as to whether the chaos of facts with which they are confronted can ever be reduced to final order

Moreover, so vast a subject can be compressed within the limits of a single short book only by the most careful and balanced selection of information, and of the sources from which this comes, and in this respect also the book leaves more than a little to be desired

With the author's main conclusions, that the present distribution of organisms chiefly reflects the catastrophic consequences of the Pleistocene glaciations, and that to understand the history of the living world its distribution in the Tertiary must be reconstructed, few biogeographers will disagree They are likely to agree also that palæogeography and palæontology are the keys to this reconstruction, but they are likely to feel some disappointment that an author so well qualified to comment on these particular aspects of the matter does not give a clearer lead as to how they may be more profitably pressed into service

The great value of the book is as a source of much useful, and not infrequently unusual, factual information, and as such it can be recommended to all who are interested in the distribution of plants and animals

RONALD GOOD

Die Banderschnecken

Eine Studie zur Evolution der Tiere Von Prof Dr F A Schilder und Dr Maria Schilder Schluss Die Banderschnecken Europas Pp iv+93–206 (Jena Gustav Fischer Verlag, 1957) Broschiert, 30 30 D M

IN this third and final part of their monumental work on polymorphism in the banded snails (*Cepaea*), Prof F A and Dr Maria Schilder have tried to give an account of the variation in all parts of the ranges of the four species, and to draw some evolutionary conclusions The booklet contains much useful information but suggests that such a task requires many more workers The maps summarizing the data may be adequate for some areas of Germany, but it is well known that the proportions of the different colour and banding forms can vary greatly between adjacent colonies , for some large areas far too few colonies have been investigated for any reliance to be placed on mean frequencies from them as truly representative

The conclusion reached is that the different forms in the polymorphisms have spread out from centres of special abundance Lamotte's work is quoted as proving that visual selection by predators can never be of importance The authors seem unaware of published criticisms of both Lamotte's conclusions, which are certainly invalid for Britain, and of their own inferences from their previous work on *Cepaea* They combine data from colonies for making inferences about selection, although some at least of those colonies are in disturbed habitats and certainly not in genetical equilibrium with their environments The composition of such colonies in relation to their habitats need give no indication that selection of any sort is acting, even though in fact it may be very strong The data are given only to the nearest 10 per cent, and are too inaccurate for re-working

A J CAIN

The Sea-Horse and Its Relatives

By Gilbert Whitley and Joyce Allan Pp ix+84 (Melbourne Georgian House, Pty , Ltd , 1958) 30*s* net

APART from a cosy introductory chapter which oozes with unsubstantiated sentimentalities, Whitley and Allan's book will be of value to interested ichthyologists as well as the children for whom it is primarily intended Besides an account of the lore and legends of sea-horses, there are good descriptions of the structure, behaviour and reproduction of this remarkable fish which Sir J Arthur Thomson once described as the "most 'kenspeckle' creature of the sea" The systematics of the sea-horse show that about a hundred species have been recorded, and these are distributed over four genera About half the book is concerned with these and the rest with pipe-fishes, trumpet fishes, flute-mouths, bellows fishes and razor fishes These, like the sea-horses, are illustrated by some remarkably fine drawings, most of which have been prepared by the authors

T H HAWKINS

RADIATION OBSERVATIONS WITH SATELLITE 1958δ OVER AUSTRALIA

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AND

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IN June 1958 the School of Physics of the University of Sydney received a cabled request from the Academy of Sciences of the U S S R asking for help with the recording of signals from *Sputnik III* (1958δ2) As a result of this request, signals from many transits during July and August were recorded with equipment kindly put at our disposal by the Radio Research Board of the Commonwealth Scientific and Industrial Research Organization

Unfortunately, details of the instrumentation aboard the satellite and of the code used did not reach us until late September 1958, and even now we do not have all the information needed for a complete analysis of the data We believe, however, that our results are of sufficient interest to be reported at this stage

Description of Apparatus

It is now well known[1,2] that among the equipment carried by *Sputnik III* is a scintillation counter Because of the large size of the crystal (a cylinder of sodium iodide, 40 mm high and 39 mm in diameter), the detection efficiency for low-energy photons is high, and fast charged particles give very large pulses, corresponding to the loss of several MeV or more In particular, the counter responds with high efficiency to bremsstrahlung photons emitted as the result of the absorption of electrons with energies of about 100 keV which collide with the sputnik

A block diagram of the photon counter and its associated telemetering apparatus is shown in Fig 1, and Fig 2 gives the pattern of the signals The second and third pulses carried the information from the scintillation counter We do not know what information the first pulse carried

Fig 1 is largely self-explanatory The anode current of the photomultiplier is integrated and fed to a bistable circuit which switches relay *A* at intervals corresponding to a loss of energy in the crystal of 2 × 10^9 eV [1] The current to the seventh dynode similarly controls relay *C*, which switches at intervals corresponding to an energy loss of 18 × 10^9 eV In addition, the last dynode was connected to a scaler which controlled the switching of relay *B*

Table 1 Positions of 1958δ2 during Observations

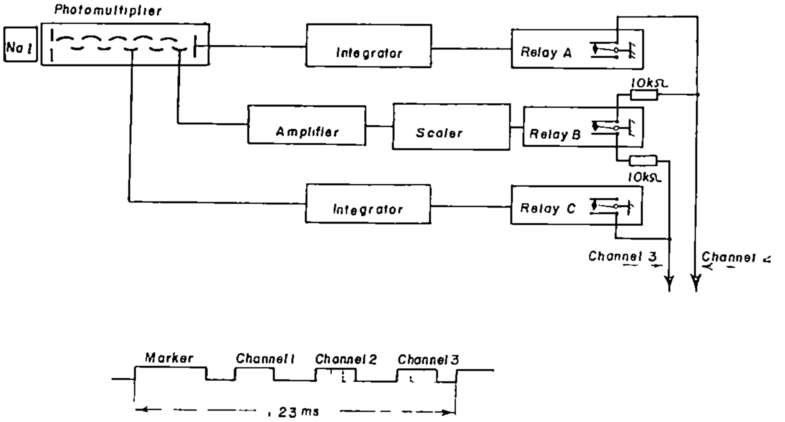
Epoch		Time (U T)	Altitude (km)	Latitude	Longitude
July 19	86806	2050	1,805	26 8° S	148 9° E
July 19	87431	2059	1,753	47 9° S	163 7° E
July 23	81250	1929	1,798	23 0° S	151 8° E
July 23	81389	1932	1,807	27 9° S	153 7° E
July 30	74514	1753	1,794	20 6° S	146 5° E
July 30	74861	1758	1,800	32 9° S	153 5° E
Aug 4	70556	1656	1,792	27 3° S	146 9° E
Aug 4	70764	1659	1,780	34 6° S	150 9° E

At the time our observations were made, the scaling circuit had ceased to operate so that relay *B* remained in a fixed position throughout So channel 2 (the second pulse) transmitted information about the position of the anode-current relay *A*, and channel 3 about the seventh-dynode-current relay On most of our records the marker and the first-channel pulse are missing as part of the modulating equipment was operating only intermittently, but the data given in this report are all taken from records in which all the pulses are present

Positions of the Satellite during Observations

The positions of 1958δ2 used by us were calculated with the aid of the elements of the orbit published by the Smithsonian Institution, and with an orbital period found from a least-squares fit to the transits observed at Sydney

The results of these calculations are given in Table 1 and displayed in Fig 3



Figs 1 (above) and 2 (below)

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* Also supported by the Nuclear Research Foundation within the University of Sydney

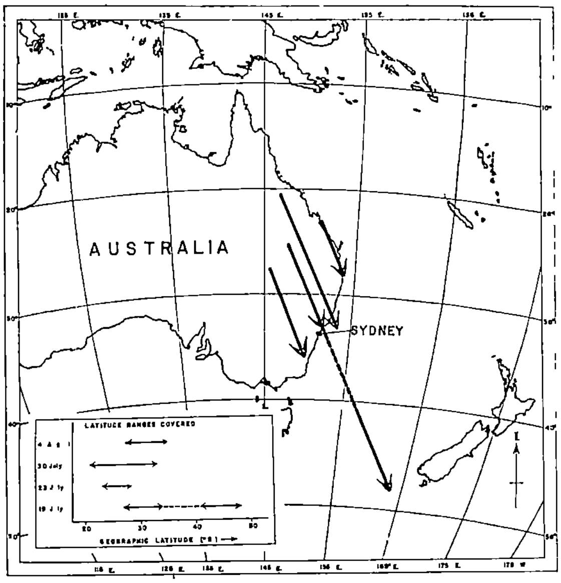

Fig 3

Results and Conclusions

The rates of energy loss in the crystal during our five recording periods are plotted as function of time (U T) in Fig 4 Combining these with the positions of the satellite (Fig 3 and Table 1) we find a minimum of radiation intensity at a geographic latitude of about 35° S The intensity appears to increase by an order of magnitude when the latitude changes by approximately ten degrees on either side of this minimum Similar observations over Australia, made with satellite 1958ε (*Explorer IV*), have been reported by Van Allen *et al* [3], who suggested that these minima correspond to outward-projecting 'horns' in the contours of constant radiation intensity The minima can presumably be interpreted as the gap between the inner and outer radiation belts which have recently been discovered by means of the Russian artificial planet[4] and by Van Allen and co-workers using the American lunar probes

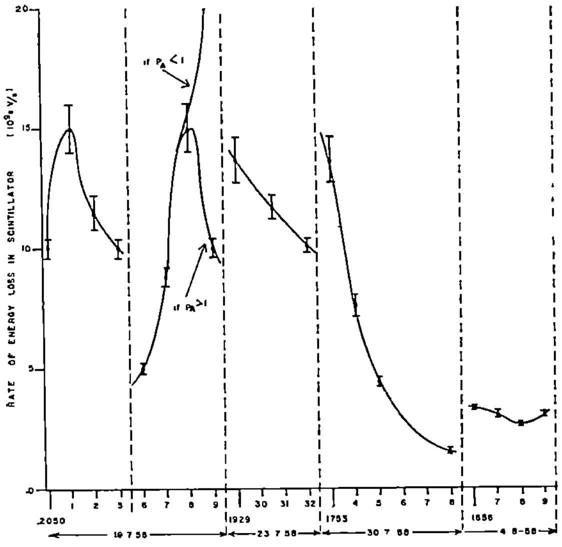

Fig 4

Our data also suggest a time variation in the radiation intensity the mean intensity during the first part of the transit of July 19 (see Fig 4) is about five times the mean for August 4 although the satellite moved through almost exactly the same region in the two cases We do not know whether the distribution of absorbing matter around the scintillator is such that tumbling of the sputnik could cause such large fluctuations , but, in any event, we do not believe that the fluctuations are so caused since our observations of the signal strength suggest a tumbling period not greater than about 40 sec — much less than our intervals of observation

We tentatively conclude that the intensity of radiation in the region observed may show very considerable variations with time This may be of particular significance as the region in question straddles the gap between the two radiation belts

Our remaining conclusions concern the ratio of the switching rates of relays *A* and *C* It appears to us that the telemetering equipment was not designed to handle the high switching rates, especially of relay *A*, which corresponds to the intensities of radiation encountered by the satellite The switching rate of relay *A* almost always overloaded channel 2 during our periods of observation We were, however, able to obtain adequate data on the rates of loss of energy through channel 3—these are the ones plotted in Fig 4

When a large charge passes through the later stages of a photomultiplier, its anode-current response becomes non-linear, and for extremely large flashes of light the current from the dynodes also becomes a non linear function of the light input The ratio of the switching rates of relays *A* and *C* therefore depends on the average magnitude of the light flashes at low counting rates, and on the average light output from the scintillator at counting rates so high that the interval between the individual events in the crystal is less than the decay time of the light pulses (about 5 μsec in sodium iodide) According to Vernov *et al* [1] the ratio of the switching rates of relays *A* and *C* is 9 1 if the photomultiplier operates in the linear region of its response curve , it will be less if an appreciable number of the pulses is caused by particles which lose large amounts of energy in the crystal, and it will also be less if the number of photons detected in unit time is extremely large

It was therefore of interest to try to find values for the switching rate of relay *A*, and we were able to do this as we explain in detail below The results show that the ratio of the switching rates was of the order of 4 1, with fluctuations in the range 3 8 1 to 6 1 Individual results are shown in Table 2 , they suggest that the ratio decreased with time As we have no information about the response curves of the apparatus we cannot draw conclusions about the nature of the radiation from this

Table 2 THE RATIO p_C/p_A

Epoch	Time (U T)	p_C/p_A
July 19 86806 to July 19 87431	2050 to 2059	5 0 ± 0 3
July 23 81250 to July 23 81389	1929 to 1932	4 4 ± 0 1
July 30 74514 to July 30 74861	1753 to 1758	3 9 ± 0 2
Aug 4 70556 to Aug 4 70764	1656 to 1659	3 0 ± 0 2

Recording Method

The receiving aerials were two horizontal dipoles placed at right angles to each other Each dipole

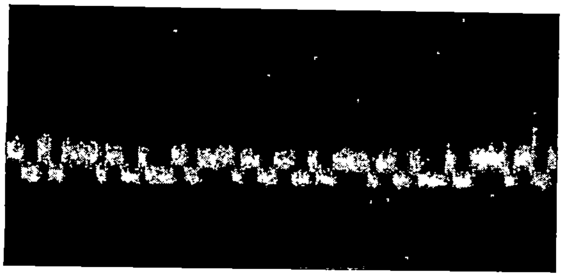

Fig 5

fed a communications receiver, and the rectified signals from the second detectors were further amplified by two separate d c amplifiers The two outputs were then summed by a resistive mixing network and the resultant was applied to the deflecting plates of a cathode-ray tube The spot was photographed on 35-mm film moving perpendicular to the direction of deflexion at a speed of 0 6 in /sec (1 52 cm /sec)

Characteristics of the Signal

A sample of one of our records, showing complete pulse trains with marker pulses and first pulses, is given in Fig 5 The pulse-lengths were measured with the aid of a travelling microscope A sample of a pulse-length distribution (for the transit of July 23) is shown in Fig 6

The various combinations of positions of relays *A*, *B* and *C* lead to pulses of nominal lengths 50, 100 and 150 μsec [1] which we designated 'short', 'medium' and 'long' As the position of relay *B* was fixed, the second-channel pulses were either long or short, depending on the position of relay *A* only, and the channel-3 pulses were of either short or medium length It is clear from Fig 6 that in both channels there occurred a number of intermediate-length pulses these were caused by the switching of a relay while a pulse is being transmitted

With the aid of time markers recorded on the film we were able to measure the pulse-lengths The results are given in Table 3

Table 3 LENGTHS OF PULSES AND PULSE TRAINS

	Nominal value* (m sec)	Measured (m sec)
Short pulses	50	69 ± 8
Medium pulses	100	115 ± 8
Long pulses	150	161 ± 10
Pulse train including marker	1,230	1,210 ± 30

* Vernov *et al* (ref 1)

Analysis of the Records

In the system of telemetering used, the positions of the relays are sampled at regular intervals of 1 23 sec (the cycle-length) A change in the length of the appropriate pulse occurs whenever the number of switchings during the preceding cycle was odd, no change is found when the number of switchings was even If a relay is switched during transmission of the pulse the length of which it controls, a pulse of intermediate length occurs

If the relay is switched at intervals which are large compared with the length of the sampling cycle, every switching results in a change of pulse-length Common sense suggests that the converse is also true that changes in pulse-length at intervals large compared with the cycle-length denote an equal number of switchings, each of which occurred during the cycle immediately preceding the change Although not strictly true, as we shall see below, this turns out to be almost always correct

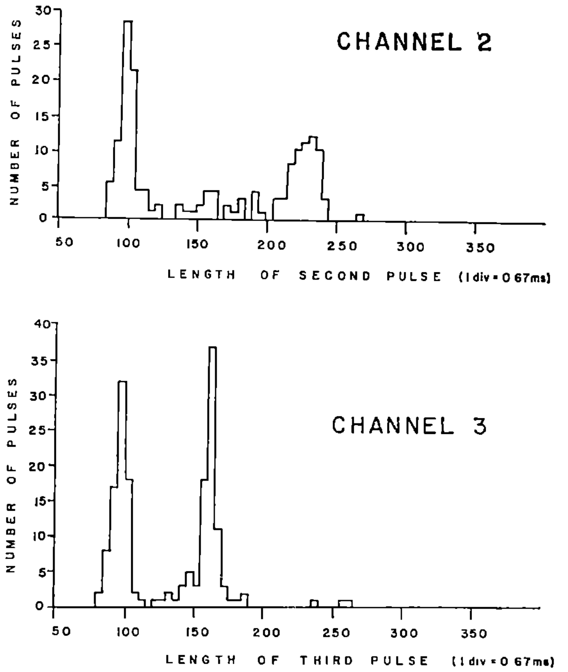

Fig 6

For more detailed analysis we plot (Fig 7) the interval between pulse-length changes as a function of the interval between switchings of the relay It is clear that if the interval between switchings were really constant, and if there were no additional information, we should not be able to deduce a unique value of the switching frequency from the observations of changes in pulse-length Fortunately, however, the intervals fluctuate, and we have other data as well

The published information shows that if the photomultiplier is working in the linear region of its anode-current characteristic, the ratio between the switching rates of relays *A* and *C* is 9 1 Overloading cannot increase this ratio, so that we accept only those pairs of switching rates which have ratios of 9 1 or less Secondly, as Fig 7 shows, the lengths of the intervals between changes are very sensitive to changes in the switching rate when there is more

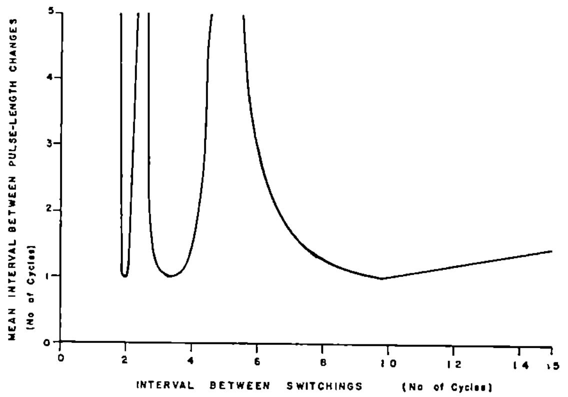

Fig. 7

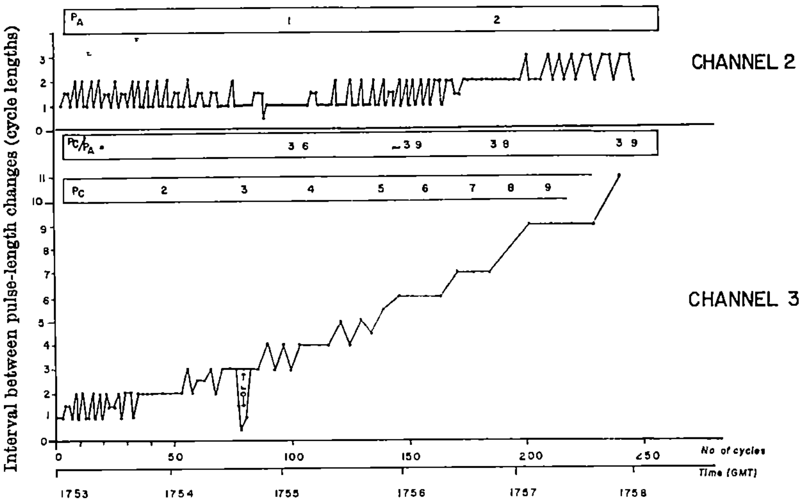

Fig 8 July 30, 1958 1753–58 G M T

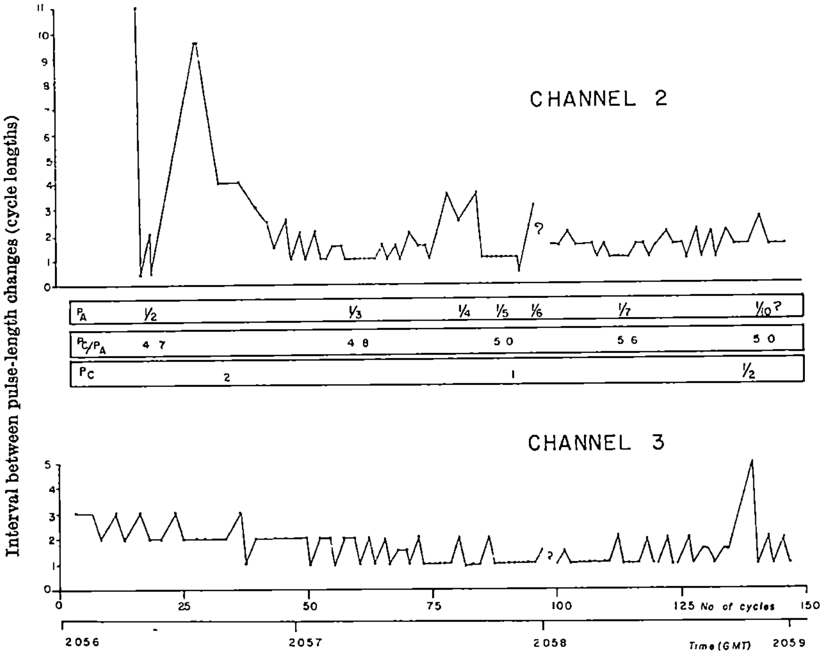

Fig 9 July 19, 1958 2056–59 G M T

than one switching per cycle In the presence of fluctuations it is thus quite unlikely for high switching rates to give rise to long successions of pulses of equal size, that is, to consistently long intervals between changes in pulse-length We conclude that if the intervals between pulse-length changes are consistently longer than the sampling cycle, the frequency of the changes is equal to the switching frequency of the relay concerned During most of our observation time the less-sensitive channel 3 operated in this way so that we could deduce the radiation intensity directly from the frequency of pulse-length changes in it

With one exception, at 1758 U T on July 30 (see Fig 4), the intervals between the switchings of relay A in channel 2 were always less than the length of the sampling cycle The intervals between pulse-length changes thus rarely exceeded two cycles, and we could not obtain information about the rate of switching from the average magnitude of these intervals alone However, for the reasons discussed earlier we felt it worth while to try to estimate the switching frequency of relay A

The possible values of the interval p between switchings can be obtained from Fig 7, and the smaller values of the intervals p_A (between the switchings of relay A) can usually be eliminated because of the requirements that the ratio p_C/p_A cannot be greater than 9 1 In most cases we were still left with several possible values of p_A from which a choice had to be made using the patterns of pulse sizes in both channels

Two additional pieces of information helped us here First, the ratio of the switching rates is not likely to show violent discontinuous changes Secondly, in spite of fluctuations, there will be a brief series of equal-width pulses (no changes) whenever the number of switchings per cycle is nearly equal to an even integer ($p = 1/n$ cycle lengths where n is even) Whenever there is an odd number of switchings per cycle there will be a series of pulse-length changes every cycle This effect, though not very pronounced, is clearly observable

In our analysis we used a graphical method of display, of which we show examples in Figs 8 and 9 Along the horizontal axis we plot the times of occurrence of changes in pulse-length, while the ordinate gives for every change the time elapsed since the immediately preceding one We also indicate on the diagrams our estimated values of p_A and p_C and of the ratio p_C/p_A The intervals p are measured in units of one cycle-length

Fig 8 shows the record corresponding to our lowest detected radiation intensity the only case when we found p_A to be undoubtedly greater than unity It can be seen clearly that p_C/p_A is approximately equal to 3 8—much less than the nominal value 9

Fig 9 is a display of data from an observation period during which the radiation intensity was high and changing rapidly According to our estimates, p_A varied from approximately 1/2 cycle to 1/10 cycle during the time covered by the diagram, and the record shows particularly clearly the peaks in the plot associated with even integral values of $1/p_A$, and the runs of pulse-length changes every cycle which occur when $1/p_A$ is odd

We should like to thank Prof. H. Messel for the excellent laboratory facilities made available to us, and Dr. G. H. Munro, the officer in charge of the Sydney Section of the Radio Research Board, for making possible the recording of the sputnik transmissions. To Academician L. I. Sedov we are grateful for an informative discussion during his recent visit to Australia, and for the reprints he presented to us. We are much indebted to Miss Xenie Federoff for the careful and conscientious way in which she carried out the tedious work of reading the records. One of us (J. O.) would like to thank the Commonwealth Scientific and Industrial Research Organization for the award of a studentship.

[1] Vernov, S. N., Vakulov, P. V., Gorchakov, Ye. V., Logachev, I., and Chudakov, A. Ye. (in Russian), "Collection of Papers on Sputnik Results", **2** (Moscow: U.S.S.R. Academy of Sciences, 1958).

[2] Chudakov, A. Ye. (privately circulated information).

[3] Van Allen, J. A., McIlwain, C. E., and Ludwig, G. H., *J. Geophys Res.*, **64**, 371 (1959).

[4] Vernov, S. N., and Chudakov, A. Ye. (privately circulated preprint).

ROBERT HOOKE AND BOYLE'S AIR PUMP

By Dr. H. D. TURNER
University of Sheffield

It is just three hundred years since Robert Hooke built Boyle's air pump. This event has been described by Gunther[1] as "the most important research ever brought to a successful issue in Oxford"; and it is perhaps appropriate to mark the tercentenary by examining the truth of this statement and, incidentally, by somewhat belatedly giving Hooke the acknowledgment which is his due for his share in the enterprise.

Robert Hooke, who was born on July 18, 1635, at Freshwater in the Isle of Wight, was the son of the local curate. He was a sickly child and never robust, but he gave early evidence of that mechanical aptitude which led to his being described as "certainly the greatest mechanick this day in the world"[2]. After the death of his father, Hooke went, at the age of thirteen, to Westminster School; and in 1653 he went to Christ Church, Oxford, as a chorister, being admitted to the degree of Master of Arts in 1663. During the latter part of his stay in Oxford, Hooke was employed as a laboratory assistant by Boyle, and in 1659 he built the air pump shown in Fig. 1.

At this time Boyle was very much interested in the mechanical properties of the air, and very dissatisfied with the behaviour of the air pump then available, that due to Otto von Guericke. In 1660 Boyle wrote his famous treatise on the "Spring of the Air"[3]. In this book, which was dedicated to his nephew, Lord Dungarvan, he says:

"As few inventions happen to be at first so compleat, as not to be either blemished with some deficiencies needful to be remedied or otherwise capable of improvement: so when the Engine we have comes to be more attentively considered, there will appear two very considerable things to be desired in it.

"For first, the *Wind Pump* (as somebody not improperly calls it) is so contriv'd that to evacuate the Vessel, there is required the continual labour of two strong men for divers hours. And next, (which is an imperfection of much greater moment) the Receiver or Glass to be employ'd, consisting of one entire and uninterrupted Globe and Neck of Glass; the whole Engine is so made, that things cannot be convey'd into it, whereon to try Experiments. So that there seems but little (if anything) more to be expected from it, than those very few *Phaenomena* that have been already observed by the Author and recorded by SCHOTTUS".

Boyle then goes on to say that he asked Hooke to contrive a more effective air pump.

"Wherefore to remedy these Inconveniences, I put both Mr. G(RATORIX) and R. HOOK (who hath also the honour to be known to your Lordship, and was with me when I had these things under consideration) to contrive some Air Pump, that might not like the other, need to be kept under water (which on divers occasions is convenient) and might be more easily managed. And after an unsuccessful tryal or two of ways propos'd by others, the last named Person fitted me with a Pump, anon to be

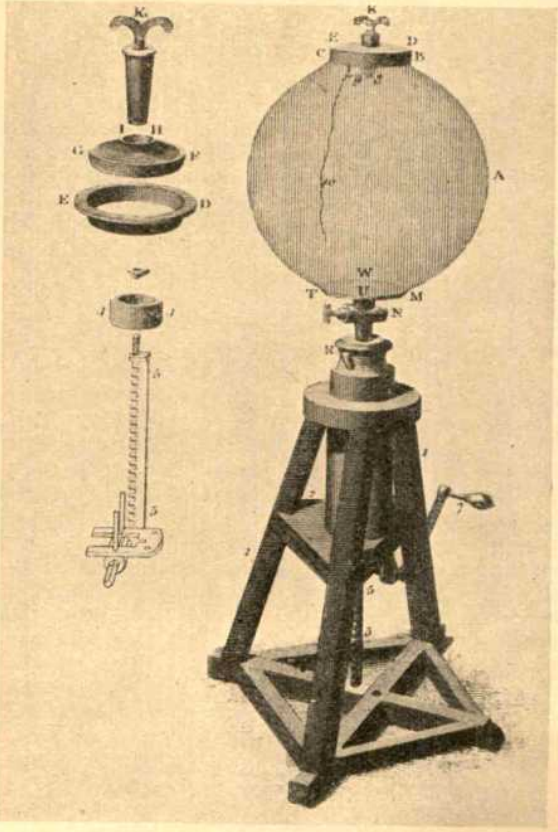

Fig. 1. Boyle's air pump, built for him by Robert Hooke in 1659. This was a notable advance on O. von Guericke's pump since the evacuated enclosure was easily accessible and the ratchet system enabled one man to operate the pump without undue effort. Hooke later built a double-acting pump which was even more effective and flexible in operation

described. And thus the first imperfection of the German Engine, was in good measure, though not perfectly remedied".

The cylinder of the pump was bored in London; but the rest of the machine was constructed by Hooke in Oxford. The technical difficulties were evidently enormous. Boyle goes on to say:

"Your Lordship will, perhaps, think that I have been unnecessarily prolix in this first part of my Discourse. But if you had seen how many unexpected difficulties *we* found to keep out the external Air, even for a little while, when some considerable part of the internal had been suck'd out, you would peradventure allow that I might have set down more circumstances than I have, without setting down any, whose knowledge, he that shall try the experiment, may not have need of".

Once an efficient air pump was available, there were many experiments which could be performed. One of the first investigations carried out by Boyle was into the relationship between the pressure and volume of a gas.

This led to the enunciation of 'Boyle's Law' or 'Boyle and Mariotte's Law' after its confirmation by Mariotte in 1676. Although Boyle does not explicitly name Hooke as his assistant and collaborator in this work, Gunther[4] believes that he was. At this time Boyle was suffering from weakness of eyesight; and he also complained of a lack of skill in geometry which made him "both unwilling and unfit to engage in any Study where the conversing with Mathematical Schemes is necessary". The suggestion is that Hooke, a skilled experimenter and a very able geometer, was, in fact, mainly responsible for the enunciation and proof of Boyle's Law.

Hooke himself carried out many experiments with the air pump. In 1662, having been released by Boyle, he went to London as curator of experiments to the newly formed Royal Society. In this capacity he had to demonstrate different experiments two or three times a week for the delectation of the Fellows; and in many of these he used either the air pump, or the condensing engine, a compressor which he built in 1662–23. For example, in April 1663 we find Hooke experimenting with water freed of air which, according to Huygens, did not subside in a Torricellian tube; and later, air was removed from above and within water containing various fish to see which would die soonest.

This work with fish undoubtedly stimulated an interest in the general problems of respiration and combustion, and we may suspect that this was not unconnected with the interest that the Royal Society was then taking in the problems of diving. In 1664 we find Hooke giving an account of an experiment with two birds, one of which was kept in compressed air and the other in air at ordinary atmospheric pressure. He also constructed a container, large enough to hold a man, which could be partially evacuated by the air pump. Hooke experimented on himself in this device, thus anticipating modern investigations into human behaviour under reduced atmospheric pressure. He tells us that when a quarter of the initial air had been extracted he was able to endure for "somewhat above a quarter of an hour without any other inconvenience than feeling some pain in his ears, and finding himself deaf". During this experiment Hooke took a lighted candle into the container and discovered that it was extinguished long before he experienced discomfort. Other experiments carried out at this time involved the development of an air gun, the measurement of air pressure and experiments with diving bells; but the most important aspect of this period of experimentation is undoubtedly the insight which the use of the air pump gave Hooke into the mechanism of combustion and respiration. The culmination of this work was, in fact, the publication by Hooke in 1664, in "Micrographia", of his theory of combustion[5].

In 1680 Denys Papin, who invented the 'digester' (the prototype of the modern pressure cooker), joined Hooke as his assistant. He later developed a 'steam pump' in which water was forced, by expanding steam, into a container from which it was ejected, under pressure, on to the paddles of a water-wheel; and this has been regarded by some French authors as the first steam engine.

Papin's claims in this direction, however, must, one feels, rest on his contributions to the development of the atmospheric engine. For some time on the Continent there had been interest in the possibility of producing power by using the pressure of the atmosphere to force a piston along an evacuated cylinder. Various ways of producing the vacuum had been tried. Guericke[6] had described an experiment in which a cylinder had been evacuated by using his air pump; Huygens[7] had blown the air out of a cylinder by the detonation of a small charge of gunpowder; and Papin[8] had used the apparatus shown in Fig. 2 to produce a vacuum by the condensation of steam. Like many other members of the Royal Society at this time, Papin was aware of the enormous problem of clearing flooded mines

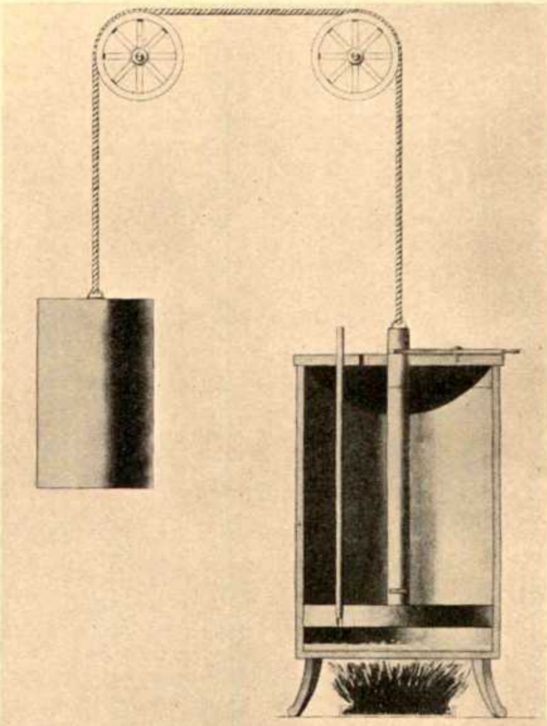

Fig. 2. Papin's cylinder and piston device, 1690. (*Crown copyright. From an exhibit in the Science Museum, South Kensington*) Steam generated by heat from the fire allowed the piston to rise to the top of the cylinder, where it was locked in position by the movable rod. The device was removed from the fire; the steam condensed by pouring cold water on the cylinder; and on releasing the piston it was forced down by air pressure, thus raising the counterbalanced weight

which were frequently distant from sources of water power In 1685 he proposed a scheme for the transmission of power over considerable distances A water-wheel was to drive two large air pumps , the air contained in pipes attached to these would be alternately rarefied and compressed , at the mine the suction and pressure would alternately lift water from the mine and then expel it In 1688 he proposed a modification of this in which a conveying pipe was to be evacuated by a water-driven air pump , at the mine the conveyance pipe was connected by branched pipes and valves to two vertical cylinders fitted with pistons , these were connected by ropes to an axle carrying a winding wheel around which was wound another rope carrying buckets at each end As each cylinder was evacuated in turn, external air pressure would force its piston down, thus turning the wheel first clockwise, then anticlockwise, and hence the buckets would be alternately raised and lowered

Hooke's influence on these projects and his contribution to the ultimate development of the atmospheric engine is now, unfortunately, undocumented Our only evidence of his interest and suggestions comes from references made by Dr Robison[9] of Edinburgh Among the latter's papers after his death was found a "List of Dr Hooke's Inventions" which contained the following sparse note, "1678 proposed a Steam Engine on Newcomen's principle", which implies that he had anticipated later developments in this field Robison also claimed to have seen, among the Royal Society's collection of Hooke's papers, memoranda of a letter addressed to Thomas Newcomen, of Dartmouth , these memoranda were, however, not in the possession of the Royal Society in 1880 According to Robison, Newcomen and John Cawley, a glazier, were anxious to make an engine on the lines suggested by Papin in 1688 Newcomen was in touch with Hooke and wrote to ask his advice Hooke had already criticized both Papin's projects on the ground that the great compressibility of the air in the conveyance pipe would result in negligible effects at the mine unless the water-driven pumps had inordinately long strokes In replying to Newcomen, Hooke said, "Could he [Papin] make a *speedy vacuum* under your second cylinder, your work is done"[10]

This suggestion was taken up by Newcomen and Cawley, who probably knew of Papin's piston and cylinder experiment and who certainly knew of the methods employed by Savery in operating his pumping machine, 'The Miner's Friend' According to Stuart[10], "They, therefore, made the experiment of introducing *steam* under a *piston moving in a cylinder, and formed a vacuum by condensing the steam by an affusion of cold water, on the outside of the steam vessel, and the weight of the atmosphere pressed the piston to the bottom of the cylinder*"

This method of producing a vacuum by the condensation of steam had been patented by Savery An agreement was therefore entered into between Savery, Newcomen and Cawley, and they were all associated in the grant of a monopoly for the atmospheric engine which was made in 1705

The construction by Hooke of the first efficient air pump undoubtedly exercised a profound effect on the development of science and technology in the second half of the seventeenth century Not only did the use of this machine lead to an understanding of the physical properties of gases and to a theory of combustion which is strikingly similar to the modern theory , but also it focused attention on the properties of systems of pistons and cylinders and the pressure of the atmosphere This was certainly important in providing the climate of opinion in which the atmospheric engine could develop , and as we have seen, there is reason to believe that in this development, too, Hooke played a decisive part

[1] Gunther, R T , "Early Science in Oxford", **6**, 8 (Oxford, 1930)
[2] Gunther, R T , "Early Science in Oxford", **6**, 6 (Oxford, 1930)
[3] Boyle, R., "New Experiments Physico-mechanical touching the Spring of the Air and its Effects, Made for the most part in a New Pneumatical Engine" (Oxford, 1660)
[4] Gunther, R T , "Early Science in Oxford", **6**, 73 (Oxford, 1930)
[5] Hooke, R , "Micrographia", 103 (London, 1664)
[6] Guericke, O von, "Experimenta nova" (1672)
[7] Huygens, C , "Œuvres Completes", **6**, **22**, **7** (The Hague, 1895)
[8] Papin, D , "Fasciculus dissertationium de novis uibusdam machinis" (Marburg, 1695)
[9] Robison, J , article on The Steam Engine, "Encyclopædia Britannica", Third Edition "A System of Mechanical Philosophy with Notes" by D Brewster (Edinburgh, 1822)
[10] Stuart, R , "A Descriptive History of the Steam Engine", 59 (London, 1824)

Information about Hooke's experiments on respiration and combustion and with the air pump has been taken from "Early Science in Oxford", vols 6 and 7

CANCER AND THE RESPIRATORY GRANA

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WARBURG'S[1] theory of the origin of cancer proposes that tissue specificity can be achieved only by the synthesis of substances which make tissues specifically different through oxidative metabolism in the grana which carry the oxidative enzymes Accordingly, the loss of tissue specificity begins with the loss of oxidative capacity through injury to the grana Since a source of energy is essential, the cell can only survive the loss of its oxidative apparatus if the oxidative apparatus is replaced by the adaptive development of the fermentative apparatus The loss of oxidative capacity is not reflected by an immediate loss of tissue specificity , but when the injured cell divides and the daughter cells begin to grow, they do not achieve tissue specificity because the energy produced by fermentative metabolism cannot produce it Warburg has focused attention on the oxidative grana of the cell , mutation, the carcinogenetic poisons, viruses, mechanical irritations, anaerobiosis, radiation and all other 'indirect' causes of cancer and influences, similar to hormonal control, are assumed to affect the autonomous grana and thus to affect tissue specificity only through their action on the grana Warburg has unified all ideas concerning the origin of cancer into a single concept involving material organelles capable of observation and metabolic investigation, thus making it possible to bring the phenomenon under test and observation. In this respect, the theory is (as Warburg says) the only explanation of the origin of cancer cells which can be "metabolically specified". The essential aspects of the theory are summarized by Warburg: "Cancer cells originate from normal body cells in *two* phases. The first phase is the irreversible injuring of respiration. . . . there is only one common cause into which all other causes of cancer merge, the irreversible injuring of respiration.

"The irreversible injuring of respiration is followed, as the second phase of cancer formation, by a long struggle for existence by the injured cells to maintain their structure, in which a part of the cells perish from lack of energy, while another part succeed in replacing the irretrievably lost respiration energy by fermentation energy. Because of the morphological inferiority of fermentation energy, the highly-differentiated body cells are converted by this into undifferentiated cells that grow wildly—the cancer cells."

Although Warburg's theory concerns the problem of dedifferentiation, it does not explain how the cell became differentiated. It has been pointed out by others that the cancer cell is not dedifferentiated back to the embryonic level but always retains some characteristics which make it identifiable with regard to origin. Thus the loss of tissue specificity does not involve complete but only partial 'dedifferentiation'.

Differentiation is also achieved in organisms in which defined cells do not exist, since the Ascomycetes, which are cœnocytial, are highly differentiated. Even though the nuclei flow freely through the false septa throughout the thallus, differentiation into mycelium, conidiophore and conidium is achieved in circumstances so fluid that no specific cell can be identified. This differentiation requires, like all other differentiation, the activity of many genes, since many nonconidial forms of *Neurospora* are known each of which is the phenotype of a different recessive allele. It may be inferred that differentiation is effected differently in cellular and noncellular organisms.

Although we all speak freely about 'yeast cells', it should be pointed out that phylogenetically yeasts are also noncellular organisms which graduate from mycelial or cœncytial forms to budding varieties all of which seem to be relatively closely related. The so-called yeast 'cell' and its bud is simply a cœncytial form which partitions single nucleate buds with a surrounding wall, much as *Neurospora* forms microconidia. Although this might seem like splitting hairs, it is a vital point in cell theory. The 'cell' that Warburg means is the cell of a multicellular organism.

A dominant scientific theory remains the dominant theory until it is replaced by a subsequent theory, because scientific effort can only be carried out under the ægis of a theory which restricts the activities and directs the efforts toward the examination of fundamental principles. Warburg's theory is to-day the dominant theory; by unifying the concept Warburg has made all other ideas concerning the origin of cancer subsidiary to his. In the absence of an alternative theory, one does not reject a theory by indicating extreme dissatisfaction with it (for example, Weinhouse[2]), since no scientific activity is conceivable without a guiding theory. The most adverse criticism notwithstanding implies acceptance *ipso facto*.

The first step in criticism of the theory is the specification of the assumptions upon which it is based. Warburg has assumed: (1) that the ascites tumour cell is a typical cancer cell; (2) that differentiation and tissue specificity in cellular organisms are achieved by oxidative metabolism of the grana (the respiratory grana have functions other than tissue differentiation, since they play an active part in the metabolism of yeasts); (3) that the grana are autonomous; and, therefore, (4) that the oxidative apparatus cannot be synthesized *de novo* (recent, unpublished, experiments in this laboratory have revealed that respiratory-deficient yeast cells, which never recover respiratory capacity spontaneously, can in certain unique conditions become respiratory-sufficient by exposure to yeast homogenates); (5) that cells which have lost oxidative capacity may obtain their energy by fermentation; (6) that division of these fermentative cells leads to the loss of tissue specificity, since they cannot obtain the oxidative energy essential to differentiation; (7) that such cells can neither fit into the tissue to perform the tissue function nor be restricted by the agents which restrict the differentiated cell and, therefore, form tumours; (8) that oxidative capacity can be injured (*a*) by oxidation of narcotics on the grana, (*b*) by direct action of specific poisons, (*c*) by anaerobiosis, (*d*) by radiation and (*e*) by various other items which are carcinogenetic. Research aimed at understanding cancer (as distinguished from applied research aimed at methods relieving the symptoms, study of surgical procedures, discovery of drugs for destroying cancer by large-scale canvasses, etc.) requires an investigation of the validity of these assumptions and a reformulation of theory depending on the results of such investigations.

Warburg's theory presupposes that the aerobic apparatus is a recent phylogenetical achievement. It is clearly a late, almost certainly the last, great advance made by the free cell in evolution, since it could only occur after photosynthesis had made oxygen available. Its recent integration into the cell probably accounts both for its autonomy and its vulnerability. (The respiratory grana and the chloroplasts are both autonomous structures which were obviously integrated into the cell recently, presumably before multicellular organisms evolved. It is reasonable to suppose that the chloroplast was the original symbiont added to the cell—or to the cœncyte—and that it later evolved into the respiratory granum with the advent of oxygen.) Since the autonomous aerobic apparatus seems universal, it may have been perfected when cells existed only as free cells, before the advent of the differentiated multicellular Metaphyta and Metazoa. The adaptive enzymic fermentation in yeasts, which is normally achieved by oxidative metabolism, may also be achieved by fermentative metabolism, albeit more slowly and less efficiently. Warburg might say that enzymic adaptation in single-celled micro-organisms is a 'cytoplasmic' activity and thus different from 'true' tissue specificity in multicellular organisms. On this theory, true tissue specificity may have appeared after the advent of oxygen.

A striking difference between yeast cells and mammalian cells lies in their means of obtaining energy. Yeast cells, unlike mammalian cells, have two separate fully functional systems for supplying adenosine triphosphate—an oxidative and a fermentative system. Yeasts can grow oxidatively or fermentatively without previous preparation, unlike the mammalian cells which can adjust themselves to a fermentative mode of existence only (according to Warburg) by slow degrees. In this sense, mammalian cells are almost obligate aerobes. No obligately aerobic yeasts are known since the anaerobic metabolism in yeasts is always available as a source of energy. In some yeasts (in which the aerobic pathway has been lost) the anaerobic pathway is the only source of adenosine triphosphate. Yeasts are markedly different from the filamentous fungi, like *Neurospora*, in which it is difficult to demonstrate the fermentative pathway and which resemble mammalian tissue in growing only poorly, if at all, under anaerobic conditions.

This discussion suggests that the yeast cell can provide a fruitful research object for study of the sensitivity of the respiratory apparatus and thus a guide in the evaluation of carcinogens. Many kinds of poisons have been tested with this view in mind. An interesting poison which was introduced to us by Dr. Seymour Hutner is propamidine isethionate. It is widely used in the tropics as a specific for kala-azar. It is thus important to know whether or not it may be carcinogenetic. Our present indications are that it destroys the respiratory apparatus too completely, too rapidly and too specifically to be a carcinogen—if the data from yeast cells are transferable to humans. When yeast cells are smeared on the surface of an agar plate, and a paper filter pad saturated with a solution of 1750 p.p.m. of propamidine isethionate is placed in the middle of the plate, a zone (several cm. wide) appears around the disk in which the yeast cells grow abundantly but in which none of the cells is capable of utilizing oxygen. Since the original cultures were respiratory-sufficient, it is inferred that propamidine isethionate has destroyed the respiratory apparatus. The living cells in the zone around the disk have been irreversibly transformed into obligate anaerobes. This is demonstrated by inoculating the cells from the zone into a peptone yeast-extract broth containing sodium acetate as the major source of carbon. The medium contains phenol red as an indicator, and if a single cell with an intact respiratory apparatus is introduced into this medium it will grow and the medium will turn deep red due to the increase in *p*H[3]. Although cells from the area surrounding the disk grow well in glucose broth, transfers to the acetate broth never produce an alkaline reaction, proving that all the cells have lost their ability to respire acetate and hence are respiratory-deficient. The conclusion that propamidine isethionate has destroyed the respiratory apparatus irreversibly seems irrefutable. It also appears to have achieved this end with relatively little harm to the cell otherwise.

This experiment is simplified by using a yeast which is incapable of synthesizing adenine, since strains of this kind with an intact respiratory apparatus are pink while the respiratory-deficient strains are white[4]. When this experiment is performed with a pink yeast, the yeast which appears in the zone surrounding the disk is white, although it remains adenine-dependent. White cells from such a plate always fail to grow after transfer to the acetate broth, justifying the inference that all the cells have lost their respiratory apparatuses since a single cell with an intact respiratory apparatus would be able to utilize the acetate and grow in the acetate broth. A poison of this type which acts abruptly and completely on the respiratory apparatus might be assumed on Warburg's theory not to be carcinogenetic because it acts so quickly and completely that the mammalian cells (which do not have a fully formed anaerobic pathway available and waiting) would not be able to adapt themselves to anaerobic growth. The phenomenon demonstrates the extreme sensitivity of the respiratory apparatus to a poison which has little or no effect on the survival of the cell.

Warburg's theory assumes that low oxygen tension can lead to crippling of the autonomous grana and thus to cancer. Warburg's inference that respiratory deficiency could be induced by anaerobiosis was confirmed by Hino and Lindegren[5] using yeast. (Respiratory-deficient yeasts, induced by anaerobiosis or by a variety of other treatments, are completely capable of maintaining their structural integrity permanently from generation to generation, although all the cell's energy is supplied only by fermentation. Warburg, quoting Pasteur, stated that "not even yeast, which is one of the lowest forms of life, can maintain its structure permanently by fermentation alone; it degenerates to bizarre forms". This view concerning the stability of yeast grown exclusively anaerobically is in error, but this fact has no bearing on the validity of Warburg's theory of the origin of cancer, since it neither supports nor invalidates any of the assumptions upon which the theory is based.) Both Sarachek[6] and Harris[7] failed to confirm the induction of respiratory deficiency in yeast by anaerobiosis. In three haploid cultures Hino and Lindegren found that the frequencies of respiratory-deficiency under aerobiosis were, respectively, 1·7, 2·8 and 3·2 per cent, while the same cultures grown anaerobically produced, respectively, 14·9, 8·6 and 8·0 per cent. Two diploid cultures under aerobic conditions produced, respectively, 0·8 and 0·0 per cent respiratory-deficiency, and 1·9 and 0·2 per cent under anaerobic conditions. In one tetraploid culture the frequency of respiratory-deficiency rose from 0·0 under aerobiosis to 0·3 per cent under anaerobiosis. It is clear that the haploid state provides the clearest demonstration of the effects of anaerobiosis on respiratory-deficiency, and it is not surprising that neither Sarachek nor Harris detected this effect, since they did not use haploid cultures. Anaerobiosis (unlike propamidine isethionate) induces only a low frequency of respiratory-deficiency; the effect of propamidine isethionate is total. Anaerobiosis produces relatively minor damages which might be progressive, if repeated, since only a few of the grana are affected in most cells and only rarely are all destroyed. Anaerobiosis is inferred to be an effective carcinogen, since it only reduces partially the energy available from aerobiosis and thus enables the cell to survive long enough to adapt the dormant fermentative system.

Recent work in this laboratory[8] has provided an example of another kind of induction of respiratory-deficiency in yeast. Caffeine induces respiratory-deficiency in yeast cells sensitive to caffeine with much higher frequency than in cells resistant to caffeine. Growth in caffeine is only achieved by an adaptive process, presumably an enzymic adaptation. Both resistant and sensitive yeast cells pass through the adaptation; but the adaptation of sensitive cells is characterized by the simultaneous induction of an extremely large number of respiratory-deficient cells. Although one may assume that the total induction of respiratory-deficiency by propamidine isethionate is due to the direct action on the grana, the induction of respiratory-deficiency which occurs when caffeine-sensitive cells become adapted to caffeine may be due to injury of grana, not by direct action of caffeine upon the grana, but through the metabolic stress imposed by oxidative adaptation to caffeine.

The metabolic stress of adaptation can be observed cytologically Several years ago when interest in the laboratory centred on adaptation of yeast to galactose, yeast cells were critically observed during adaptation In the early stage of adaptation most cells were not budded and did not stain with methylene blue (Non-stainability is the standard criterion for viability) Just before adaptation was achieved (as indicated (1) by the absence of budding , (2) by the failure to accumulate glycogen , (3) by slow utilization of galactose) nearly all cells became stainable with methylene blue In other circumstances this would indicate that the cells were non-viable Shortly thereafter, however, at least 80 per cent of the cells produced buds, lost their stainability with methylene blue, and vigorous fermentation of galactose occurred This is interpreted to mean that the stress of adaptation had exhausted most of the reducing reserves of the yeast cell, permitting it to stain with methylene blue, but that this deficiency was made up as soon as sufficient galactose became available

An important use of Warburg's theory is for predicting the possibility that an agent is a carcinogen from its action on the respiratory grana On this theory, propamidine isethionate is predicted not to be carcinogenetic whereas anaerobiosis and caffeine are The dye janus green, which acts specifically to stain the respiratory grana and which is singularly effective in preventing sporulation in yeasts, is predicted to be non-carcinogenetic Incidentally, the sporulative process in *Saccharomyces* is an especially useful point for testing the effectiveness of various toxic agents on the respiratory grana, since it is a highly specific kind of differentiation which is achieved only aerobically The view that viruses may cause cancer can also be deduced directly from Warburg's theory Warburg inferred that a great variety of metabolic disturbances could inactivate the respiratory apparatus, and experimental evidence from yeasts supports his views Since many viruses grow in the cytoplasm without killing the cell, they are disturbers *par excellence* of cytoplasmic metabolism and might be expected readily to cause the destruction, inactivation or malfunction of the grana Viruses inhibiting the nucleus would be predicted to be not nearly so effective

Ephrussi[9] was the first to speculate concerning the chemical mechanism by which the respiratory grana of the yeast cell could be destroyed He assumed that since acriflavine has an affinity for nucleic acids it was mutagenic and he found that it induced respiratory deficiency Ephrussi was unaware of the fact that Stier and Castor[10] had previously induced respiratory deficiency with cyanide, and Whelton and Phaff[11] had shown that ethylene oxide is extremely efficient in producing the same effect It has become increasingly evident that a great variety of substances induce respiratory deficiency in yeasts copper and manganous salts are recent additions Whether these substances act directly as propamidine isethionate appears to, or indirectly as temperature[12] and caffeine adaptation, it seems clear that study of the phenomenon should be revealing in terms of the nature of the respiratory grana and, therefore, of carcinogenesis

This work has been supported in part by a research grant from the American Cancer Society

[1] Warburg, O , *Science*, **123**, 309 (1956)

[2] Weinhouse, S , *Science*, **124**, 267 (1956)

[3] Tavlitzki, J , *Rev Can Biol* , **10**, 48 (1951)

[4] Ogur, M , Lindegren, G , and Lindegren, C C , *J Bacteriol* , **68**, 391 (1954)

[5] Hino, S , and Lindegren, C C , *Exp Cell Res* , **15**, 628 (1958)

[6] Sarachek, A , *Cytologia*, **23**, 143 (1958)

[7] Harris, M , *J Cell and Comp Physiol* , **48**, 95 (1956)

[8] Maddox, P , and Lindegren, G , *Bacteriological Proc* , abstract, 28 (1959)

[9] Ephrussi, B , *II Annales de l'Institut Pasteur*, **76**, 1 (1949)

[10] Stier, T J B , and Castor, J G B , *J Gen Physiol* , **25**, 229 (1941)

[11] Whelton, R , and Phaff, H J , *Science*, **105**, 44 (1947)

[12] Sherman, F , thesis, Univ of Calif , Berkeley (1958)

THE NEW MARINE BIOLOGICAL STATION ON HELIGOLAND

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MANY years before the island of Heligoland passed from British to German ownership in 1890, it was popular with distinguished scientists from Germany and other Continental countries for marine biological pursuits, because the waters bordering the German mainland yield only a small part of the faunal range characteristic of the open sea

In the Baltic, the low salinity of the German waters there is a limiting factor and in the North Sea the turbidity is such Moreover, in the North Sea the wide belt of mainland shore which dries out at low tide militates against the establishment of a first-rate German marine biological station there Well before 1850, men whose names were to become world-famous in the domain of marine biology were frequenting Heligoland because of the much better natural conditions which exist there

So long ago as 1835, Ehrenberg had investigated the origin of bioluminescence while working on the island and, ten years later, Johannes Muller had there formulated new ways of investigating the life of the open sea In 1865 Anton Dohrn (later of Naples fame) and Ernst Haeckel of Jena were conducting researches from the island, and, within two years of its cession to Germany, a marine biological station had been founded with F Heincke as first director During the twenty-eight years of his tenure of the post, his famous work on the natural history of the herring and on the plaice was carried out In those days the Station was housed in more than thirteen separate buildings and its own staff of eight scientists and sixteen technical assistants had to find room for sixteen guest workers Not until it was possible (in 1920) to take possession of a large building freed from naval use did it become possible to conduct tuition courses, and the first of these was attended by a class of thirty

Many British oceanographers will well remember Heincke's successor—the genial and talented W. Mielck, who was head of the Station during

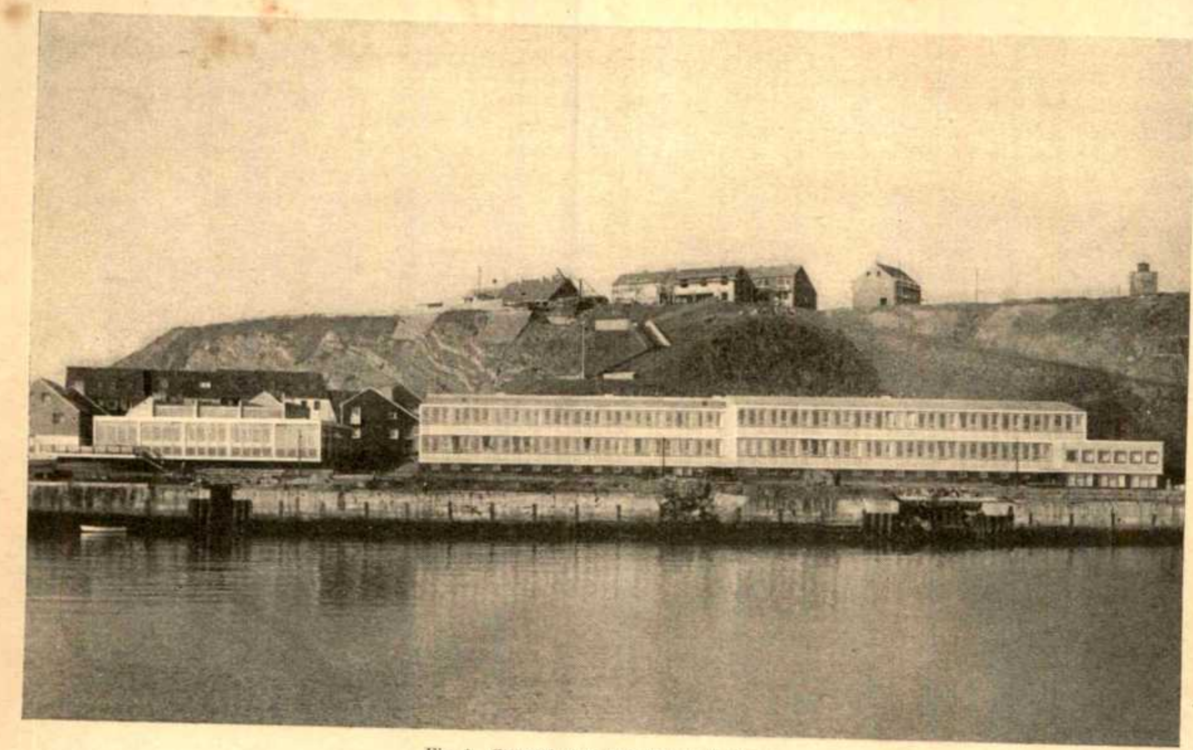

Fig. 1. General view from the water front

1920–33. When its enlargement was completed in 1937, the name "Wilhelm-Mielck-Haus" was given to part of the multi-storied construction. The last director of the Station to be appointed before the Second World War was A. Hagmeier, who held the post on the island from 1934 until after hostilities had broken out. He remained the nominal director of the Station until his death in 1953. Until shortly before that time, he had been resident in Sylt at the dependent Ellenbogen Station near List. While there Hagmeier spent much effort in the furtherance of marine biological research and was able to adapt a vacated army building in List to provide a two-roomed laboratory on the harbour side in which instructional courses could be given. Already by 1949 the number of visiting students had reached 170. When, in 1952, the island of Heligoland was made free of access again and declared ready for building operations to start, Hagmeier was already prepared with plans for reconstituting the renowned Biologische Anstalt on it. Though it is not by any means the case that all German marine scientists were in favour of the project, the marine biologists for the most part were so.

In pre-1939 days, the "Biologische Anstalt Helgoland" came under Prussia and one may read, in old reports of the Government, of that State having furnished 400,000 marks for the rebuilding which began in the winter 1925–26. when serious thought was given to rebuilding the completely demolished Station some years after the end of the Second World War, however, the island had come under Schleswig-Holstein. This *Land* not being financially able to shoulder the expense of such an ambitious project, it came about that the *Bund* Ministry of Land, Food and Forests eventually did so.

Much space would be needed to give an adequate account of the impressive proceedings of June 19 last, when the fine new Station which has arisen on the ruins of the old was formally declared open in the presence of a large concourse headed by Bundesminister Dr. Lübcke, who has since been elected President of Western Germany in succession to Dr. Heuss. Ministers of Schleswig-Holstein were present; German oceanographers were there in number; guests from the Netherlands, Italy and Britain attended, and an English fisheries research vessel (*Sir Lancelot*) had come from Lowestoft. The Director of Fisheries Research in Britain was present, greatly to the gratification of Dr. A. Bück-

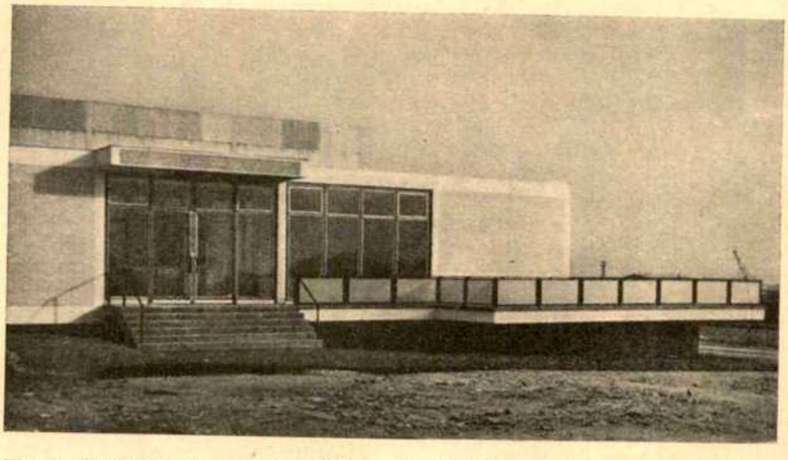

Fig. 2. Entrance to the aquarium with (on the right) the verandah around the seal basin

mann, director of the new Station, who recalled the close associations between Lowestoft and Heligoland during the years between the wars. Most of the guests had been carried from Cuxhaven in the very fine German research vessel *Anton Dohrn*, which has already much first-class work to her credit despite her youth.

Speeches and a tour of the new Station were the business of the first day—followed by a reception and supper aboard the *Anton Dohrn*. The second day (June 20) was devoted to a scientific conference in the commodious lecture room. After a *Festvortrag* by Dr. J. Verwey of Den Helder, he opened a general discussion on what should be the scientific activities of marine stations. After this topic had been debated very widely with no lack of participants, Dr. A. Bückmann gave a very detailed account of the programme of work which he has in view for his fine new Station. From what he said it was quite clear that great care had been taken to build as economically as possible in erecting the long low buildings which are such a contrast to those standing when the former building programme ceased in 1937. Because practically everything had to be transported from the mainland at great additional expense and with dependence upon weather, it is perhaps not surprising that the cost to the *Bund* Ministry was in the neighbourhood of six million D.M. (about £6/11 million).

The divisions of activity provided for under the general leadership of Dr. A. Bückmann, who remains resident in Hamburg, where he is professor of fisheries biology in the University of Hamburg, are : zoology, animal physiology, botany, microbiology, planktonology and fisheries biology. The first of these divisions has a staff of three scientists with the Director as leader. The other divisions have two scientists each, except for microbiology, which has only one. It seemed surprising that there is no special provision for the hydrographical work which is essential before a proper study can be made of the relationships between the marine fauna and flora and the environment. An island like Heligoland must afford wonderful opportunities for studying what differences exist in the marine life as between what must usually be the lee and weather sides.

There are many things of great interest with which a worker trained in the physical side of oceanography could occupy himself working from the new Station. Questions elicited the remarks that expense had to stop somewhere, but that visiting workers on any aspect of oceanography would always be made most welcome—as evidenced by the great amount of laboratory space set aside for guests.

It is a very praiseworthy feature of post-War German marine science that excellent collaboration exists between the Heligoland activities led by Dr. Bückmann, the German Hydrographic Institute, the German Scientific Commission for Marine Research, the Institute for Fisheries Biology of the University of Hamburg, the Bremerhaven Institute for Marine Research and the University of Kiel. This close working together has led to really notable achievements in respect of investigations on the high seas, and German oceanographical investigations made during the Polar Front Survey within the International Geophysical Year programme are of high merit.

Along the southern face of the main block of the new Station are the laboratories in use by the staff and the rooms used for the dispatch of animals to universities and other customers. The northern face contains the laboratories for guest workers and students. The public aquarium, with all its complicated technical 'plumbing', and the aquaria for research and growth studies constitute a separate block. An impressive feature of the aquarium which those with memories of the pre-War Station will recall has been provided anew and in duplicate. Quite detached and centrally placed are a pair of circular 'tanks' in the form of very large glass vertical cylinders rising to a considerable height from the floor. Co-axially placed within each of them is an opaque vertical cylinder of considerable diameter which has a sanded surface. As a result, fast-swimming fish such as herring, mackerel and hake can swim swiftly around and around in the annular water space without knocking into the external glass or being crowded into corners. It is a wonderful sight to see the fish incessantly swimming around on their (to them) endless journey. Great value is attached to the fine supply of excellent sea-water pumped in from the end of a mole, and to the fact that all the 'plumbing' is of plastics. One sees handsome arrays of bright green and red piping more or less everywhere. The Station's cutter *Uthorn*, which is 24·5 metres long, of 6·4 metres beam, and of draught 2·6 metres, does 8 knots under the drive of her 150 h.p. engine. She is excellently equipped with instruments and is of great use in enabling the scientists to dredge in the Heligoland Rinne, which is one of the deepest parts of the southern North Sea and has a fauna of particular interest. Two motor-boats are also available.

It was emphasized that to run a marine biological station to-day is a vastly different affair from what it was in Anton Dohrn's day. The mass of expensive and costly apparatus which had already become necessary a decade and more back has been much added to by the requirements for work with carbon-14 and other isotopes. The new Heligoland Station is well equipped for work with eight or more tracer elements.

Heligoland was always a favourite holiday resort, and already some eleven hundred permanent inhabitants are housed again on the island to make the most of it. 'Day tripping' from the mainland is also a very intense and paying business. During the summer the multitude of visitors contribute to the Station's funds by way of their payments to visit the aquarium. In winter when the visitors no longer come, the scientists of the Station can use the large annular 'tanks' described above of 25 m.^{3} capacity for studies on the swimming of migratory fish.

About fifteen guest investigators pursuing quite different lines of work can work in association with the thirteen scientists of the Station, and great help is given in the matter of lodging to guests whose visits take place in summer. By throwing two large classrooms into one, thanks to a movable partition, a lecture room with ample accommodation for fifty students becomes available. Provision is made for visiting university teachers to bring students to the Heligoland Station for classes lasting some weeks, and facilities are afforded for teachers of biology and others to attend refresher couses.

The complex of buildings, which has a total frontage of 120 metres, includes a special basin in which a seal will live. This, with glass 4 cm. thick, is most ingeniously constructed. Outside, walking on a balcony, paying visitors will be able to look down on the seal from above. From inside the building the visitors will look into the tank illuminated by daylight from above, and will see many smart movements imposed upon the seal by the clever internal 'architecture' of the tank. This fine basin recalled the modest accommodation which the seal living in the Heligoland aquarium many years ago had to be content with.

As with the Station of former times, the very appropriate speech from Goethe is in evidence. It now faces us set into the wall in large bronze capitals as we enter through the main public door "Alles ist aus dem Wasser Entsprungen, alles wird durch das Wasser erhalten, Ozean gonn uns Dein ewiges Walten".

It was due to the kind generosity of the *Bund* Ministry that I was able to attend the impressive re-opening. For those who would know very much more about the new Biologische Anstalt Helgoland, a full account written by its director exists[1] and a shorter one by one of his assistants[2].

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[1] Buckmann, A., *Helgol Wiss Meeresunters*, 7, Heft 1, 1–50 (Hamburg, 1958).

[2] Hempel, G., *Die Umschau*, 12, 353–4 (Frankfurt am Main, 1959).

OBITUARIES

Prof. E. Percival

A GREAT blow has been dealt to marine and freshwater biology in New Zealand by the death on July 15, in Christchurch, of Prof. Edward Percival. Prof. Percival, who was born in 1893, was elected to the chair of biology at Canterbury University College, as it was then called, in 1928 after serving as lecturer in the Department of Zoology at the University of Leeds, where he was assistant to the late Prof. Walter Garstang. During 1928 he worked as a temporary naturalist in the Plymouth Laboratory on the ecology of the Rivers Tamar and Lynher, and he will be well remembered by those who knew him then. The son of a Cheshire farmer, Percival spent his boyhood in Lancashire, where he took the national diploma in agriculture at the Harris Institute, Preston, and he found much to interest him when he came to New Zealand. His early work on the ecology of rivers in Yorkshire led him to play a prominent part in trout management in acclimatization society work in New Zealand, and his experience in marine biology in the United Kingdom was put to good use in guiding his research students and in advising the policies of various government departments.

His published work, amounting only to about a score of papers, is not a sufficient criterion by which to judge the man. He had declined various academic honours since he maintained that such things were of no use to him. He did, however, consent to be elected a Fellow of the Royal Society of New Zealand.

First and foremost he was a teacher. From the elementary- to the postgraduate-level he never failed to bring out the best in the human material set before him. His particular philosophies on the teaching and appreciation of biology will be long remembered by all those who came in contact with him, even if only as incidental associates.

For his advanced students he held a twice-yearly field expedition to Menzies Bay, one of the isolated little coves on Banks Peninsula, and he took his students into the field on almost every other week-end during term, bringing a certain spartan approach to the pleasures of animal observation which helped one more fully realize what is meant by ecology. His aim was to produce, at the postgraduate-level, a student well balanced in outlook, able to think, not to be a storehouse of facts but to know where to turn to find what is already known, and potentially able to go on in almost any field of biological endeavour. How successful he has been in this can be seen by the wide distribution of his honours students in various positions throughout the world.

The informal, and often quite unzoological, discussions which he held in the field and in the well-remembered atmosphere of his rooms, together with his novel methods of allowing notes to be taken into the examination room, all helped to bring out what powers of expression and thought were available in his students. Indeed, he often remarked that he wished he could conduct his examinations in the University library, for he would know even more easily the worth of his candidates.

Physically he was outstanding for a man near retirement, and in the field his stride and energy in every activity proved more than a match for even the most athletic of his followers.

At the first encounter he presented a rather forbidding aspect and was inclined to be of uncertain temperament, but this, particularly in his later years, was a variation on the theme of not suffering fools gladly. If one genuinely wanted help, advice or encouragement and if one had exercised all one's resources before approaching him, Percival became the proverbial tower of strength and it was difficult not to find oneself being cast in his mould.

Apart from his long-term studies on lakes in the Canterbury foothills and his interests in marine matters, his scientific work will long be remembered for his fine studies on the embryology of the Brachiopoda. Percival was fortunate in having a locality close by where these animals could easily be taken between tides on the rocky shore and he was able to use his advantage to the full in producing his studies on their development and growth. He was never afraid to admit that he was wrong or that he did not know, an attitude of mind which had its effects particularly on his elementary students contemplating a career in teaching.

Percival's influence extended far beyond the cloisters of the University of Canterbury, and it would be hard to exaggerate just how widely his teaching and stimulation have been, and will continue to be, felt.

ELLIOT W. DAWSON

Dr M. R. Schafroth

DR MAX ROBERT SCHAFROTH and his wife, Kathi Schafroth (*née* Gemperle), died on May 29; they were killed in an aeroplane crash in Northern Queensland, Australia.

Dr Schafroth was born in Burgdorf, Switzerland, on February 8, 1923. He passed his matriculation at the Gymnasium in Bern in 1949. He then entered the University of Bern in order to study mathematics and physics, later changing to the

Swiss Federal Institute of Technology in Zurich. He graduated at the latter in 1948, obtaining a diploma in mathematics and physics.

Thereafter he commenced research work under the direction of Prof. W. Pauli, who was professor of theoretical physics at the Institute and Nobel prizewinner of 1944. Dr. Schafroth obtained his doctorate degree in 1949 and was thereafter appointed as assistant to Prof. Pauli—a post he held until 1953. During that time he continued research in collaboration with Prof. Pauli in quantum field theory and solid state physics.

At this stage the Schweizer Arbeitsgemeinschaft fur Mathematik und Physik offered him an overseas travel grant for two years, which he decided to spend in the Department of Theoretical Physics of the University of Liverpool with Prof. H. Frohlich. After one year in Liverpool, however, he left Europe to accept a lectureship offered him by Prof. H. Messel in the then newly expanded School of Physics at the University of Sydney. He remained at the University of Sydney until his death, having been promoted to a senior lectureship on January 1, 1955, and to a readership on January 1, 1957. In May 1958 he was invited to accept the chair of theoretical physics at the University of Geneva, Switzerland, which invitation he had accepted and intended taking up this post on September 1, 1959.

Starting mainly with his stay with Prof. Frohlich in Liverpool, Dr. Schafroth became interested in the theoretical understanding of the phenomenon of superconductivity. This was also his chief research interest during his five years at the University of Sydney. He published several penetrating papers on this subject himself and also inspired contributions from others in the School. There can be no doubt that his work in this field will go down in science as having been a major contribution to the understanding of superconductivity. Several papers by him are yet to appear. These include a review of the field in the series "Solid State Physics", edited by Profs. Seitz and Turnbull.

Apart from this particular field of research, Dr. Schafroth was an expert and inspiring lecturer in the fields of statistical mechanics, solid state physics in general and quantum field theory. He brought into his lectures something of the qualities of his old teacher, Prof. Pauli.

The death of Robert Schafroth and of his wife Kathi will be a great loss to all who knew them.

S. T. BUTLER

Mr. H. W. Greenwood

THE death of Mr. H. W. Greenwood occurred on April 30 at the age of seventy-seven. In the course of a very active life, Mr. Greenwood was associated with three industries. Before the First World War he was a mining plant superintendent in the south of Spain. In 1919 he joined Leto Photo Materials Company, manufacturers of photographic paper, and continued with the firm after their amalgamation with Wellington Ward and their later amalgamation with Ilford, Ltd. Since 1937 he had been associated with Powder Metallurgy, Ltd.

Mr. Greenwood wrote profusely in all three subjects, papers and books of a popular but well-informed nature. For many years he was an important contributor to the *British Journal of Photography*.

W. D. JONES

NEWS and VIEWS

Electrical Engineering at Newcastle upon Tyne: Prof. J. C. Prescott

PROF. J. C. PRESCOTT, professor of electrical engineering at King's College, Newcastle upon Tyne, retires this year. He was elected in 1937, succeeding W. M. Thornton, who was the first holder of the chair. After studying at the University of Liverpool under Prof. E. W. Marchant, he entered a college apprenticeship with the British Westinghouse Company in 1915, continuing later with that Company as research engineer. He saw service with the R.N.V.R. during the First World War, being attached to H.M. Mining School at Portsmouth. After the War, he returned to the University of Liverpool as lecturer in electrical engineering, where he was to remain for 18 years. His early researches were concerned with the behaviour of constant-current dynamos, and this led by way of a study of the free period of coupled alternators to researches on the inherent instability of parallel connected synchronous electrical machinery. His papers of this period reveal that electrical measurement and measuring instruments were also occupying a substantial part of his time. For this work he was awarded the degree of doctor of engineering by the University in 1931. In Newcastle his research work has been concerned with synchronous governing of alternators, and further studies of the stability of parallel-connected alternators have been made; latterly he has been engaged in an investigation into the performance of turbo/alternator governors, which is still in progress.

The Department of Electrical Engineering at Newcastle has grown greatly in size during Prof. Prescott's tenure of the chair. Under his direction the expansion has been conducted so as to preserve a balance between so-called 'light' and 'heavy current' electrical engineering, and to avoid too early specialization in undergraduate courses. Always playing a large part in the teaching activities of his Department, he has consistently emphasized the necessity for the teaching of fundamentals in university courses, and has always insisted upon the maintenance of a high academic standard in his Honours School. Like his predecessor, he has been active in the affairs of the Institution of Electrical Engineers, being chairman of the North Eastern Centre in 1943–44, and has taken a continued interest in the North East Radio and Measurements Group. Coming from a literary family, he is a man of uncommonly wide interests who holds the respect and affection of all who know him. His friends both inside and outside the University wish him many years of active and happy retirement.

Dr. R. L. Russell

DR. R. L. RUSSELL, who has been appointed to the chair of electrical engineering at King's College, Newcastle upon Tyne, in succession to Prof. J. C. Prescott, graduated B.Sc. in 1938 and M.Sc. in 1939, in mathematics at the University of Leeds. Soon afterwards, he took up work in the Admiralty Degaussing Department at Portsmouth and Helensburgh, and thus his first contacts with electrical engineering were made. In 1942, when the magnetic mine had been overcome and there was an acute demand for radio mechanics, Dr. Russell accepted lectureships on radio training courses, first at the Royal College of Science and Technology, Glasgow, and then at Robert Gordon's Technical College, Aberdeen. He went from Aberdeen to the Research Department of the British Thomson-Houston Co. at Rugby. In 1946, he was appointed as lecturer in the Department of Electrical Engineering in the University of Bristol, and in 1955 he was promoted to a readership.

Towards the end of the War he published certain papers of a semi-geometrical nature, mainly arising out of problems in radio engineering. As time has proceeded, he has turned his essentially geometrical mind to a number of problems, first in electrical measurements and then in relation to electrical machines. Many papers have been published in the *Proceedings of the Institution of Electrical Engineers* arising out of this work, which led to Russell receiving the degree of D.Sc. from the University of Leeds a few months ago. Dr. Russell's most individual contribution to electrical engineering has been to observe the possibilities which arise from feeding a three-phase winding simultaneously at both ends with voltages of different frequencies. This principle has already had several applications, and it is of interest to note that Russell's predecessor in Newcastle, Prof. J. C. Prescott, adopted the idea in relation to synchronous governing. A recent Ph.D. thesis on synchronous governing presented at King's College incorporated just such a double-fed device.

Agricultural Botany at Leeds: Prof. J. H. Western

Dr. J. H. Western has been appointed to the newly instituted chair of agricultural botany within the Department of Agriculture in the University of Leeds. He was educated at Avoncroft Agricultural College, Evesham, and the University College of Wales, Aberystwyth, where he graduated in botany with agricultural botany. In 1937 he was awarded the degree of Ph.D., the subject of his thesis being "Some Aspects of Biological Specialization in the Oat Smut Fungi". In that year, he also took up an appointment at the Welsh Plant Breeding Station, Aberystwyth, where he undertook research on diseases affecting herbage plants. In 1939 he was appointed lecturer in agricultural botany and adviser in mycology in the University of Manchester, leaving in 1946 to take up appointment as provincial plant pathologist to the Northern Province, Ministry of Agriculture and Fisheries, Newcastle upon Tyne. In 1951 he was appointed to his present post of senior lecturer in agricultural botany in the Department of Agriculture in the University of Leeds. His investigations have included the problem of the 'choke' disease of cocksfoot (*Dactylis glomerata*) caused by the fungus *Epichloe typhina*, and he has been responsible for numerous publications.

Physiology at King's College, London: Prof. R. J. S. McDowall

The retirement is announced of Prof. R. J. S. McDowall from the Halliburton chair of physiology at King's College, London. This he has held for thirty-six years. He has perhaps become best known for his books. The most outstanding is "Control of the Circulation of the Blood", a monumental work with more than 9,000 references; but his "Handbook of Physiology", of which he has produced eleven editions, has been the bible of a generation of medical students. His "Sane Psychology" has been reprinted four times. Prof. McDowall's interests have been chiefly in the circulatory system in which he has been an untiring worker and is a recognized authority. He gave the Oliver Sharpey Lecture of the Royal College of Physicians in 1939 on this subject. He has also been largely responsible for the formation of the Asthma Research Council and in recognition of this he was made president of the fourth European Congress of Allergy held in London in September. His enthusiasm and powers of inspiration are reflected by the fact that thirteen of his pupils have become professors and, of these, six have been in the University of London.

Prof. J. L. D'Silva

Prof. J. L. D'Silva has been appointed to succeed Prof. R. J. S. McDowall. Prof. D'Silva first graduated in 1929 from King's College in chemistry. His early interests were in organic chemistry and he was elected Sir Halley Stewart Fellow in 1933. His attentions then turned to physiology, and appointments leading to the readership in physiology at St. Bartholomew's Hospital Medical College followed. Here he pursued his particular interests in the effects of adrenaline and adrenaline-like substances on serum electrolytes. In 1948 he was appointed to the chair of physiology at the London Hospital Medical College where his research contributions to the understanding of respiratory mechanics again reflected his early interest in the physical sciences.

University of Malaya in Kuala Lumpur: Prof. R. S. Huang

In the article under the title "University of Malaya in Kuala Lumpur" in *Nature* of August 1, p. 306, it was stated that Prof. R. A. Robinson had been appointed to the chair of chemistry. It has now been announced that Prof. Robinson has declined the appointment, which has been accepted by Prof. R. L. Huang, reader in chemistry in the University.

Prof. Rayson Lisung Huang was educated in Hong Kong, first at Munsang College and then at the University of Hong Kong. After a year as demonstrator in chemistry at Kwangsi University, China, Dr. Huang went to the University of Oxford with two scholarships, from the Rhodes Trust and the British Council, to study under Sir Robert Robertson. He gained his doctorate as a result of this period of research on synthetic hormones. Dr. Huang then visited the University of Chicago with a postdoctoral fellowship and studied for two years under the late Prof. M. S. Karasch, and then joined Prof. Konrad Bloch as a research associate for a further year. During these periods Dr. Huang worked on free radicals and on the biosynthesis of cholesterol, respectively. He joined the University of Malaya early in 1951 and has been awarded the degree of D.Sc. for his researches mainly in the field of free radicals. A citizen of the United Kingdom and Colonies, Dr. Huang has a good knowledge of classical and modern Chinese, and speaks several Chinese dialects. His scholarship in a wide field will be a most valuable contribution to the professoriate of the new Division of the University of Malaya.

The Second Russian Space Rocket

A Russian multi-stage rocket was launched at about 9 hr U.T. on September 12 and its final stage, weighing 1,511 kgm. (3,331 lb.) when empty of fuel, was projected towards the Moon with a speed of 7 miles per sec. At 18h. 40m. U.T. on September 12, when it was about 90,000 miles from the Earth, the vehicle emitted a cloud of sodium vapour. This was observed from eastern Europe and Asia as a glow, which lasted about 5 min. and was of stellar magnitude 5, in the constellation of Aquarius. At an unspecified point on its journey, the vehicle divided into two parts, an instrumented sphere weighing 390.2 kgm. (860 lb.) and the spent rocket. The sphere carried instruments to measure the magnetic fields of the Earth and Moon, the zones of radiation around the Earth, cosmic rays in space, the impacts of micrometeorites and the composition of interplanetary gas. It was stated that these experiments were successfully accomplished. The vehicle carried radio transmitters operating on some of, or all, the frequencies 19.993, 19.997, 20.003, 39.986 and 183·6 Mc./s. The radio signals ceased abruptly at 21h. 02m. 24s. U.T. on September 13, when the instrumented sphere struck the surface of the Moon at long. 0°, lat. 30° N., near the crater Archimedes.

While the vehicle was above the horizon in Britain, it was tracked by the Jodrell Bank radio telescope; the measurements made, of the direction, the Doppler frequency and the moment of impact, all confirmed that the vehicle followed very closely the trajectory given by the Russians. This second space rocket was similar to the first (launched on January 2, 1959; see *Nature*, 183, 83), which had a total weight of 3,245 lb., including 797 lb. of instruments in a spherical container, and performed similar experiments. The trajectories of the two rockets were also similar—both took about 35 hr. to reach the vicinity of the Moon—though the first rocket, instead of colliding with the Moon, flew past it to become the first artificial planet.

Rocket Studies of Emissions caused by Solar Flares: National Science Foundation Grant

The National Science Foundation has made a grant of 250,000 dollars to the U.S. Naval Research Laboratory for rocket observations of ultra-violet and X-ray emissions from solar flares. Principal investigator of the project is Dr. Herbert Friedman, superintendent of the Atmosphere and Astrophysics Division of the National Research Laboratory. The effect of the Sun's emissions upon the ionosphere and the resulting radio communication problems are of great theoretical and practical significance. Measurement and understanding of the origin of these emissions will be basic to an understanding of the solar flares themselves. Dr. Friedman will therefore launch a series of instrumented *Nike-Asp* rockets to make the necessary observations. The investigation will explore wave-lengths and altitudes at which only rudimentary observations have so far been made. Previous work by Dr. Friedman, Dr. Richard Tousey, and their co-workers at the National Research Laboratory has established the existence of intense radiations from the Sun in the wave-length regions under consideration. Dr. Friedman and his group at the Naval Research Laboratory were pioneers in the use of rockets for astronomical research, and astronomers credit his work with being among the most exciting and significant at present being carried on in the field. Instrumentation for the series of rocket observations will include Geiger counters to measure X-rays in the 1–10 A. range, X-ray detectors for wave-lengths of 8–20 and 44–60 A., scintillation counters sensitive to hard X-rays in the 20–500 kV. range, and ion chambers sensitive to the helium emission lines at 584 and 314 A.

British Aid for Nato Scientific Courses

Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, stated in the House of Commons that the United Kingdom contribution to the fund established by the North Atlantic Council to promote international gatherings for the advanced study of special scientific topics would be about £7,000 in the first year and would be borne on the vote of the Department of Scientific and Industrial Research. This was a written answer on June 25 in response to a request for a statement regarding United Kingdom participation in the new North Atlantic Treaty Organization scheme for advanced study institutes. The funds would mostly be used for contributions to the teaching and administrative expenses of selected courses at institutes in a Nato country which offered intensive courses, usually at postdoctoral to professional level, in branches of the natural sciences and technology. Assistance might also be given to the travelling and scholastic expenses of participants from Nato countries.

Graduates and National Service

In answering a question in the House of Commons on June 8, the Minister of Labour, Mr. Ian MacLeod, said that he was not prepared to extend the deferment arrangements for science and engineering graduates to men with other qualifications. This was the advice of his Technical Personnel Committee, which had considered last autumn difficulties said to be created for firms engaged in nuclear engineering and other industries by the call-up of non-graduates engaged on research. It was extremely difficult to distinguish between all the different professional qualifications that non-graduates have, but Mr. MacLeod said he would be willing to receive a deputation of research directors to discuss a definition which might be as effective as the graduate definition, if Mr. Blenkinsop, his questioner, cared to organize such a deputation.

Research and Development Charges in Civil Nuclear Power

A question was asked in the House of Commons on June 15 regarding the proportion of research and development charges for the civil nuclear power programme borne by public funds through the Atomic Energy Authority. The Paymaster General, Mr. H. Maudling, in reply said that all research and development expenditure incurred by the Atomic Energy Authority was originally borne from public funds. However, it was intended that the expenditure attributable to the civil power programme should be recovered in due course in the form of royalties payable on the electricity stations and as part of the price charged for fuel elements. The Authority also recovered the cost of the consulting services from the electricity boards.

Nuclear Reactor *RB* Accident in Yugoslavia

Volume 9 of the Bulletin of the Boris Kidrich Institute of Nuclear Sciences contains twenty-five articles and two laboratory notes of technical interest contributed by members of the physics, physical chemistry and radiobiology laboratories of the Institute They are prefaced by a statement in French by the director of the Institute, Prof P Savić, concerning the unfortunate accident which occurred to the nuclear reactor, *RB*, on October 15, 1958, at the Institute Six people, who were very close to the reactor, received strong doses of neutron and ionizing radiations and two others, who were not so close, doses above the permissible level The six were given medical treatment at the Curie Hospital in Paris, but one, V Zivota, a nuclear physicist, died on November 15 The reactor, *RB*, is of zero energy and is fuelled with natural uranium and moderated with heavy water Details of the construction of the reactor are given in the first article in the volume The safety system consists of a control key, safety rods, alarm dose-rate meters and an automatic shut down The approach to criticality is made by gradually raising the heavy-water level The accident occurred when the reactor went out of control in becoming critical Prof Savić includes in his statement the conclusions of the committee of inquiry set up by the president of the Federal Commission for Nuclear Energy to report on the accident On October 15, the committee reports, neither the alarm dose-rate meters nor the automatic control were functioning, and the personnel were judging the state of the reactor by the amount of ozone they could smell in the air The rise in power of the reactor had been detected by the strong increase in gamma-radiation, within an interval of ten minutes, on automatic recorders of the activity in the atmosphere, placed at 540 metres from, and in direct line with, the reactor An estimate of the radiations received by the injured persons is given in the article and shows that a total dose of about 683 rems was received, of which about 388 rems was by neutrons The amount received individually varied according to the distance of the person from the reactor, and was about 15 per cent less than the quoted value for the farthest distant.

The Japanese Nuclear Power Station

THE March number of the General Electric Company's *Atomic Energy Review* (2, No 1) includes an artist's impression of the 150-MW nuclear power station designed to be erected at Tokai Mura, 65 miles north-east of Tokyo, and which will be Japan's first nuclear power station The General Electric Co Ltd has been selected exclusively to negotiate a contract for its erection The station will be powered by a single gas-cooled graphite-moderated reactor of the same basic type as the two reactors at present being built at Hunterston, but will include many novel features, particularly with regard to structural and control considerations It will take approximately four years to build and is expected to be in operation by mid-1963 Other articles in the issue include a description of the General Electric Company's atomic energy division by K J Wootton, manager of the division , a discussion of the first sixteen months civil engineering construction at Hunterston by F W Evans , examples of corrosion problems in gas-cooled reactors by M W Davies , and an account of two methods of reducing the permeability of reactor-quality graphite by D A Boyland

Technical Books

THE Atomic Energy Commission of the United States has issued a catalogue of 86 technical books published by the Commission, 1947–59 (Technical Information Service Technical Books sponsored by the U S Atomic Energy Commission Pp 40 Washington, D C United States Atomic Energy Commission, 1959) The list is arranged by subjects and the contents of each volume are indicated The second part of the catalogue similarly lists 26 books in the press or in preparation on April 1, 1959

Nutrition Meeting

THE Nutrition Meeting for Europe of the Food and Agriculture Organization of the United Nations at Rome, June 23–28, of which the report has now been published (Report Series No 21 Report of the Food and Agriculture Organization Nutrition Meeting in Europe, Rome, Italy, 23–28 June 1958 Pp ix+28 Rome Food and Agriculture Organization of the United Nations , London H M Stationery Office, 1958 , 2*s* 6*d* , 0 50 dollar), was concerned with food consumption with special reference to fat consumption and with education and training in nutrition. With regard to the first, the meeting recommended the Organization to take all possible steps to foster improvements in the techniques of food consumption surveys, and of the reporting and analysis of their results, so as to ensure their maximum utility It also recommended periodical meetings of European nutrition workers and that an expert committee or study group, in co-operation with the World Health Organization, should consider the problem of fat consumption and coronary disease in European and other countries The need for further extensive studies of the fatty acid content of foods is emphasized in the report and also of further research to establish satisfactory tables for fatty acid composition The present situation was reviewed with respect to education and training in nutrition, stressing the lack of suitably trained teaching staff The contact between competent research groups, educational authorities and teachers was also considered Further, reference was made to the narrow and unbalanced approach in teaching nutrition and the absence of refresher courses for teachers dealing exclusively or incidentally with nutrition The meeting strongly supported the plea for a seminar in 1959 to study these questions in greater detail and to suggest better practical approaches The main purpose of the seminar would be to examine the scope and effectiveness of education and training in nutrition in Europe It would also formulate proposals for developing and orientating such training by government departments and other agencies, and to promote co-operation and co-ordination between the disciplines and agencies concerned and between those engaged in training and research The report outlines an agenda for a seminar of 12–14 days for 50 to 60 people

Central African Scientific Research

A FURTHER 105 papers published in 1957 by members of the staff and research workers associated with the Institute for Scientific Research in Central Africa are listed in the second part of the tenth annual report of the Institute, making a total of 792 Brief abstracts of these papers constitute the rest of this part of the report (Institut pour la Recherche Scientifique en Afrique Centrale Dixième Rapport Annuel, 1957 Pp 228 Bruxelles Institut pour la Recherche Scientifique en Afrique Centrale, 1959) In the administrative report, which is illustrated, the director, Prof L van den Berghe, indicates briefly the general character of the scientific work of the Institute during the year Prof van den Berghe continued his own study of the biology of the tsetse flies of Bugesera and Mimuli (Ruanda) and at Jiangi, and also on the sexual and asexual cycles of *Plasmodium atheruri* Other work was concerned with the isolation of factors of growth of trypanosomes, and a histopathological study of the hypophysis of small African mammals In nutrition, besides an extensive study of maternal milk and the variation of its content of amino-acids and proteins as a function of the period of lactation, the nutritional value of native beers was also investigated in the region of Lake Kivu and Ruanda-Urundi and the experimental kwashiorkor of swine was studied An investigation of the fauna of the Belgian Congo and Ruanda-Urundi was launched and also of the methods and seasons of reproduction of the birds of Tshibati In physical anthropology a study of the growth of Africans in Ruanda-Urundi was initiated and besides an inquiry into the rural economy of Ruanda-Urundi, one was commenced into the low birth-rate of the people of the Mongo tribe In the physical sciences observations of solar radiation and of the radio-electric activity of the Sun continued, as well as studies of the functional efficiency of dwelling houses at Bagira, Kabunambo and Usumba

International Council of Scientific Unions

The Yearbook of the International Council of Scientific Unions, 1959 (Pp 77 The Hague International Council of Scientific Unions, 1959), provides a comprehensive reference work on the unions Besides lists of members of the Executive Board, national members of the Council, of countries adhering to the Union, and of officers of the International Scientific Unions, it gives the membership of the Special Committees and other organs of the International Council There is also an alphabetical list of these officers and members, the Statutes and Rules of the Council, the text of the agreement between the International Council and the United Nations Educational, Scientific and Cultural Organization and the reports for 1957–58 of the Secretary-General of the International Council The Commissions of the Unions are also detailed and there is a calendar of arrangements for 1959

No 2 of Volume 1 (1959) of the *International Council of Scientific Unions Review* includes D L V Berkner's presidential address to the eighth General Assembly of the Council It also includes the remarks of Sir Harold Spencer Jones, the secretary general, on some affairs of the Council and the reports of the Special Committees for the International Geophysical Year, for Oceanographic Research and for Antarctic Research The constitution of the Committee on Contamination by Extra-Terrestrial Exploration and of the Committee on Space Research is recorded and the report of the former committee is also given This Committee believes that there is a real danger that exploration attempts made within the next few years may produce contamination of extra-terrestrial bodies, which would complicate or render impossible more detailed studies when the technological problems of landing sensitive scientific instruments on the Moon and planets have been solved It recommends that a specific code of conduct representing a reasonable compromise between the early initiation of lunar and planetary exploration and the need to safeguard future research should be drafted with the minimum of delay

Council for the Preservation of Rural England

The twenty-eighth annual report of the executive of the Sheffield and Peak District Branch of the Council for the Preservation of Rural England for the year 1959 (Pp 28 Sheffield Council for the Preservation of Rural England, Sheffield and Peak District Branch, 1959) is seriously concerned as to the preservation of the National Parks It emphasizes the importance of public opinion exerting effective pressure through such bodies as the Council for the Preservation of Rural England if the Peak District National Park, and other national parks, are not to be seriously damaged At the present time the executive is seeking to prevent the desecration of the Manifold valley by a motor road and is opposing a major attack on the Green Belt of the Sheffield Development Plan—at Middlewood in the Don valley With the local authorities and others the Branch vigorously opposed the proposals to prospect for opencast coal in the Troway valley, but the recent Government statement that areas of natural beauty will no longer be marred for this purpose should put an end to prospecting in this area It is pointed out, however, that absence of national funds prevented the Peak Park Branch from petitioning against the Waterworks Bill which proposes to submerge the Oler valley, one of the few remaining valleys leading to the heights of the Peak District National Park

Society of Environmental Engineers

A Society of Environmental Engineers has been formed to provide a forum, by meetings, publications and visits, for the exchange of information and views among those engineers who are concerned with the development of equipment to withstand shock, vibration and other forms of environmental conditions, and who carry out research in these fields The first meeting was held in London on May 29 Some fifty members and guests attended and papers reviewing the field of work were presented by Mr D A Nutt (Armstrong Whitworth Aircraft, Ltd), Mr F I L Knowles (Ministry of Supply) and Dr P Grootenhuis (Imperial College of Science and Technology) Future meetings are to be on November 25 and February 17 at the Imperial College The first annual general meeting of the Society will be held on March 30 at the Royal Society of Arts Further information can be obtained from the Secretary, Society of Environmental Engineers, 42 Manchester Street, London, W 1

Progress of Chemical Engineering

In the presidential address to the Institution of Chemical Engineers on April 28, Sir Hugh Beaver discussed the development and progress of chemical engineering in Britain, particularly in comparison with other countries Pointing out that chemical engineering was now acknowledged as the fourth great technology, Sir Hugh thought that the Zuckerman Committee's estimate of our requirements of chemical engineers was too low The figure of about 4,400 was below the present membership of the Institution—5,900 in 1959, and recent calculations of membership put the figure for 1965 at 8,800 and for 1967 at 11,100 Although the rate of increase had changed greatly in the past eight years, only in the past two or three had it approached the rate of increase in the United States All these calculations, however, involved a change of attitude and policy as well as of methods in British industry as would enable industry to absorb these numbers, and Sir Hugh regarded the increased application of chemical engineering as a measure of the use of modern techniques of manufacture Referring to the training of the chemical engineer, Sir Hugh favoured our system of three, or at most four, years college education followed by practical training He also said that the works training must be scientific and methodical, carefully thought out and systematically applied, and the system of education, while avoiding the specialization of the Continent, must produce a sufficient proportion of research students None of the industrialists he consulted had any doubts as to the need for a broad-based training, but Sir Hugh stressed the need for an open mind on this subject With regard to research, he felt that much more should be sponsored, especially industry Further, liaison between industry and university was essential for our national progress

Haida Carvers

A DEPOSIT of the hard, dark shale called argillite was discovered in the Queen Charlotte Islands in the 1820's, and Haida Indian carvers soon began to exploit it as a material for a variety of objects, which they sold as curios This has continued to the present day Many of the objects are miniature copies of the larger carvings in wood, especially totem poles and chests, but tobacco pipes, bowls and plates were often made and are common in museum collections There are also rarer objects, such as flutes

Prof Marius Barbeau is well known for his work on the North-West Coast Indians, and has recently published another of his many monographs on the subject (Canada Department of Northern Affairs and National Resources National Museum of Canada Bulletin No 139 "Haida Carvers in Argillite" By Marius Barbeau Pp viii+214 Ottawa Queen's Printer, 1957 3 dollars) It is a sequel to his previous book, "Haida Myths illustrated in Argillite Carvings", and it deals, as its title implies, chiefly with the carvers themselves, but it is a complete work in itself It is packed with information, but is somewhat haphazardly arranged There are numerous illustrations but no list of them, and there is a table of contents but no index, the nature of the material puts difficulties in the way of providing an adequate index, but the book would have been easier if a list of the objects illustrated had been given, grouped according to their present location A brief account of the carvers at the village of Skidegate is followed by five sections, each dealing with a particular type of object, and the remainder consists of notes on individual carvers The book is full of interest, and the carvers, many of whom the author has known personally, live again under his hand There has been a tendency to deprecate these argillite carvings, on the ground that they were mostly made for sale and hence were a product of acculturation and not truly indigenous Prof Barbeau has done a great service in directing attention to their value as works of art in their own right, made by skilled carvers who not only worked faithfully in their own traditions, but were also capable on occasion of representing extraneous objects in their own style

New Floristic Studies

ATTENTION may be directed to two new and considerable floristic studies C Schweinfurth has added a further contribution on the "Orchids of Peru" (published in *Fieldiana Botany*, 30, No 2; Chicago Natural History Museum, March 1959, 4 dollars 50 cents) The work is in the usual format for this series, and is mainly devoted to two considerable genera, namely *Pleurothallis* and *Epidendrum* Ten other genera with a smaller number of species are also considered All the available information has been used in preparing this volume, though some of the records are understandably still rather scanty The publication is well illustrated by line drawings

J P M Brenan has made a further contribution to the "Flora of Tropical East Africa", the portion now published dealing with Leguminosae subfamily Mimosoideae (publ Crown Agents for Oversea Governments and Administrations, London, May, 1959, price 12*s*) The main features of the subfamily are set out together with a bibliographical commentary and there is an analytical key to the genera based on vegetative and fruit characters, there are also analytical keys to the species within individual genera The text contains much useful descriptive matter dealing with distribution, habitat, etc, and is illustrated by line drawings

Royal Commission for the Exhibition of 1851

THE following awards have been made for 1959 *Senior Studentships* D W Barnes (University of Oxford) for research in pure mathematics at Tubingen, P J Goodford (University of Oxford) for research in pharmacology at Oxford, A V Grimstone (University of Cambridge) for research in zoology at Cambridge, D O Hayward (Imperial College of Science and Technology) for research in physical chemistry at the Imperial College of Science and Technology, M Wells (University of Cambridge) for research in physics at Cambridge The Senior Studentships are of the value of £800–£900 a year and tenable ordinarily for two years *Overseas Scholarships* G F O Langstroth (Dalhousie University) for research in physics at University College, London, A J McComb (University of Melbourne) for research in plant physiology at King's College, London, J W White (University of Sydney) for research in physical chemistry at Oxford, Miss S G Page (University of New Zealand) for research in biophysics at University College, London, A Chisholm (University of New Zealand) for research in physics at Liverpool, M H Proctor (Trinity College, Dublin) for research in biochemistry at Cambridge, A J Ganguly (University of Delhi) for research in organic chemistry at the Imperial College of Science and Technology, London, M Jameel (University of Karachi) for research in physics at Cambridge The Overseas Scholarships are of the value of £550–£650 a year and tenable for two or three years

American Academy of Arts and Sciences Foreign Honorary Members

THE American Academy of Arts and Sciences, at its 179th annual meeting on May 13, in Boston, elected 113 new Fellows from the United States, and 21 new Foreign Honorary Members as follows: Sir John Eccles, Australian National University, Canberra, Jean Brachet, Université libre de Bruxelles, Georges Braque, Paris, Albert Camus, Paris, Jean Leray, Collège de France, Paris, Max Born, Bad Pyrmont, Germany, George Keith Batchelor, Cambridge, Sir Isaiah Berlin, Oxford, Sir Lawrence Bragg, Royal Institution, London, Frank C Francis, British Museum, London, Anna

Freud, London, David Keilin, Cambridge, P B Medawar, University College, London, Sir George White Pickering, Oxford, Ronald Syme, Oxford, Federico Chabod, Croce Institute, Naples, Hitoshi Kihara, National Institute of Genetics, Misima, Carlos Chavez, Mexico City, M. G J Minnaert, University of Utrecht, Alf A Sommerfelt, University of Oslo, A N Kolmogorov, Academy of Sciences, Moscow

At the same meeting Dr Kirtley F Mather, emeritus professor of geology, Harvard University, was re-elected president for another year

University News.

Bristol

The following appointments have been made Dr J T Martin to a readership in chemistry of insecticides and fungicides Lectureships have been conferred on Dr E W Abel (inorganic chemistry), Dr R F Burbridge (electrical engineering) and R H. C Penny (chemical pathology, veterinary)

University College, Dublin

Dr A L Kapoor of the National Chemical Laboratory, Poona, has been appointed an I C I Fellow in Chemistry at University College, Dublin

Liverpool

The following appointments have been made to take effect from October 1 Dr B Collinge, reader in physics, Dr P M Sheppard, reader in genetics The following have been appointed to senior lectureships Dr A. K Holliday, inorganic and physical chemistry, Dr N S Jones, marine biology, Dr T M Flett, pure mathematics, Dr A Ashmore, physics; Dr H D Parbrook, physics-acoustics, Dr V H Leck, electronic engineering, Dr R S Benson and Dr N G Calvert, mechanical engineering, Dr F T W. Jordan, veterinary preventive medicine

University College of North Staffordshire

Dr D J E Ingram, at present reader in electronics in the University of Southampton, has been appointed professor of physics, to take effect from October 1

Nottingham

The following appointments have been made to take effect from October 1 Dr K J Standley, to a readership in physics, Dr G E Lamming, to a readership in animal physiology, Dr M Woodbine, to a readership in agricultural microbiology

Sheffield

The following appointments have been announced Dr D E Bourne, lecturer in applied mathematics, Dr R S Duff, senior lecturer in medicine, I E Gillespie, lecturer in surgery, D W Warrell, lecturer in obstetrics and gynaecology, L Grimshaw, lecturer in psychiatry

Swansea

Prof F Llewellyn Jones, professor of physics, University College of Swansea, has been appointed acting principal of the College until such time as a new principal takes office

Announcements

Dr P T Haskell has been appointed deputy director of the Anti-Locust Research Centre, London, in succession to Dr T H C Taylor, who became director on the retirement recently of Dr B P Uvarov (see *Nature*, 183, 1160, 1959) Dr Haskell has been at the Centre since 1955, and was previously lecturer in entomology in the Imperial College of Science and Technology, London Most of his published work has been concerned with sensory physiology, especially the production and perception of sound in insects

Dr Carl F Kossack, formerly head of the Department of Mathematics and Statistics at Purdue University, has joined the research organization of the International Business Machines Corporation at the Lamb Estate Research Center in the Town of Cortlandt, New York Dr Kossack is manager of the newly formed Statistics and Operations Research Department Dr Kossack gained his B A and M S degrees in mathematics at the University of California and his Ph D degree in mathematical statistics from the University of Michigan

A joint meeting of the Challenger Society and representatives from the marine laboratories (Development Commissioners' scheme) will be held at the Guildhall, Conway, North Wales, on October 28 and 29 Further particulars of the meeting can be obtained from Dr H O Bull, Dove Marine Laboratory, Cullercoats, Northumberland

The U S S R Academy of Sciences began to publish in the Russian language in 1959 the following new journals (in brackets, the first figure indicates number of issues per annum, the second figure, the price in roubles per annum) *High Molecular Compounds* (12, 150), *The Geology of Ore Deposits* (6, 72), *Palæontological Journal* (4, 60); *Radiochemistry* (6, 72), *The Physics of the Solid Body* (12, 150), *Cytology* (6, 72), *Soviet Slavic Studies* (4, 50)

The Commonwealth Scientific and Industrial Research Organization of Australia has issued a pamphlet listing the Organization's Divisions and Sections, as at January 1, 1959, giving the address of each and its laboratories, and the names of the Officers-in-Charge State Committees are also listed Publications of the Organization, to December 31, 1958, including those of its predecessors, are listed in a separate pamphlet

Volume XV of the Collected Papers of the Rowett Research Institute (Bucksburn Rowett Research Institute, 1959) contains an account of work of the Institute, lists of members of its governing body and scientific staff and of 88 published papers, reprints of most of which are available, as well as a summary, by the Director of the Institute, of the contents of published papers of the Institute 1957–58 so arranged as to indicate the scope, continuity and integration of the research programme Two subject reviews are also included by J J Bullen on experimental reproduction of enterotoxæmia of sheep and by J Duckworth on Institute research on the skeleton in lactation and growth

The Department of Scientific and Industrial Research will shortly resume publication of its *Technical Digests*, last issued in 1957 Their object is to direct attention to useful ideas appearing in technical literature, and following an initial free distribution to industrial firms they will be available at an annual subscription of £3 3*s* A reduction will be offered for supplies in quantity The digests will be published monthly, each being printed on a separate sheet of paper

THE TWO CULTURES AND THE SCIENTIFIC REVOLUTION

SIR CHARLES P SNOW'S Rede Lecture* for 1959 carries forward to a significant extent the old arguments concerning those subjects commonly spoken of as the humanities on one hand and the sciences on the other The teaching of the history and sociology of science to arts students and the teaching of the history of art and literature to science students is better than nothing, though it is difficult to see how the history of science can make much impact without a knowledge of the methods and results of scientific investigation The corpus of knowledge of all types is now so vast that it is foolish to look back to a Hellenic or Thomistic attempt at a synthesis

Sir Charles Snow is both a literary man and a scientist and is able to see each side of the problem from the other He seems to find the smug, self-contentment of many of the literary men more dangerous and irritating than the failure of some scientists to realize the implications of their own work in the broader field of human knowledge and aspiration "Why do most writers take on social opinions which would have been thought distinctly uncivilized and démodé at the time of the Plantagenets ? Wasn't that true of most of the famous twentieth-century writers ? Yeats, Pound, Wyndham Lewis, nine out of ten of those who have dominated literary sensibility in our time—were they not only politically silly, but politically wicked ? Didn't the influence of all they represent bring Auschwitz that much nearer ?"

But it is ill-considered of scientists to judge writers on the evidence of the period 1914–50 Literature changes more slowly than science It has not the same automatic corrective and so its misguided periods are longer

"At one pole, the scientific culture really is a culture, not only in an intellectual but also in an anthropological sense Its members need not always completely understand each other—biologists more often than not will have a pretty hazy idea of contemporary physics—but there are common attitudes, common standards and patterns of behaviour, common approaches and assumptions This goes surprisingly wide and deep It cuts across other mental patterns, such as those of religion or politics or class In their working, and in much of their emotional life, their attitudes are closer to other scientists who in religion or politics or class have the same labels as themselves At the other pole, the spread of attitudes is wider It is obvious that between the two, as one moves through intellectual society from the physicists to the literary intellectuals, there are all kinds of tones of feeling on the way But I believe the pole of total incomprehension of science radiates its influence on all the rest That total incomprehension gives, much more pervasively than we realize, living in it, an unscientific flavour to the whole 'traditional' culture, and that unscientific flavour is often, much more than we admit, on the point of turning anti-scientific Once or twice I have been provoked (by the 'non-scientists') and have asked the company how many of them could describe the Second Law of Thermodynamics The response was cold it was also negative Yet I was asking something which is the scientific equivalent of Have you read any work of Shakespeare's ?"

Little purpose is served by cataloguing the dismal ignorances in many arts people of the simplest, fundamental principles of science "The separation between the scientists and non-scientists is much less bridgeable among the young than it was thirty years ago , then they managed a kind of frozen smile across the gulf Now the politeness has gone and they just make faces It is not only that the young scientists now feel that they are a part of a culture on the rise while the other is in retreat It is also, to be brutal, that the young scientists know that with an indifferent degree they will get a comfortable job while their contemporaries and counterparts in English or History will be lucky to earn 60 per cent as much No young scientist of any talent would feel that he is not wanted or that his work is ridiculous as did the hero of Lucky Jim , and in fact some of the disgruntlement of Amis and his associates is the disgruntlement of the under-employed arts graduates "

Sir Charles insists that we should completely re-think our education "Nearly everyone will agree that our school education is too specialized But nearly everyone feels that it is outside the will of man to alter it Other countries are as dissatisfied with their education as we are, but are not so resigned Because of our intense specialization, alleged by schoolmasters to be dictated by the Oxford and Cambridge Scholarship examinations, we have set ourselves the task of producing a tiny élite—far smaller proportionately than in any comparable country—educated in one academic skill " Snow takes as an example the old Cambridge Tripos which seemed to be perfect in all respects save one The one exception was—so the young creative mathematicians, such as Hardy and Littlewood, kept saying —that the training has no intellectual merit at all They went a little further and said that the Tripos had killed serious mathematics in England stone dead for a hundred years

While we are beginning, after many years, to understand the scientific and social implications of the industrial revolution and to understand the development in teaching technology in Germany in the nineteenth century and in the United States and U S S R in later years, we are still far from grasping the meaning of the scientific revolution, by which is meant the transformations made in industry and its effects because of electronics, atomic energy, automation and modern forms of machine tools

We have failed to keep pace with the new scientific revolution—"roughly if we compare like with like and put scientists and engineers together we are training at a professional level per head of the population one Englishman to every one and a half Americans to every two and a half Russians In Russia the gap between the cultures does not seem to be as wide as it is with us If one reads contemporary Soviet novels, for example, one finds that their novelists can assume in their readers—as we cannot

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* Published by the Cambridge University Press

—at least a rudimentary acquaintance with what industry is all about' The latest figures of graduates trained per year (scientists and engineers combined) are roughly United Kingdom, 13,000 , United States, 65,000 , U S S R , 130,000 One-third of Russian graduates in engineering are women "It is one of our major follies that we do not in reality regard women as suitable for scientific careers We thus divide our pool of potential talent by two "

"We are left with a population twice as large as we can grow food for, so that we are always going to be *au fond* more anxious than France or Sweden, and with very little in the way of natural resources—by the standard of the great world powers, with nothing The only real assets we have, in fact, are our wits Those have served us pretty well, in two ways We have a good deal of cunning, native or acquired, in the arts of getting on among ourselves that is a strength, and we have been inventive and creative, possibly out of proportion to our numbers Given these two assets, and they are our only ones, it should have been for us to understand the scientific revolution first, to educate ourselves to the limit and give a lead In some fields, like atomic energy, we have done better than anyone could have predicted Within the pattern, the rigid and crystallized pattern of our education and of the two cultures, we have been trying moderately hard to adjust ourselves The historical warnings are all there For instance, the Venetian Republic in its last half-century was guided by patriot men, who had immense political skill, who knew that the current of history had begun to flow against them They were fond of the comfortable pattern of their life, just as we are fond of ours They never found the will to break it "

There is yet another danger The large masses of poor in the undeveloped countries will not allow themselves to live for ever in a world in which large sections have become rich through industry A new missionary spirit, both human and technical, is essential

"Closing the gap between our cultures is a necessity in the most abstract intellectual sense, as well as in the most practical When those two senses have grown apart, then no society is going to be able to think with wisdom For the sake of the intellectual life, for the sake of this country's special danger, for the sake of the western society living precariously rich among the poor, for the sake of the poor who need not be poor if there is intelligence in the world, it is obligatory for us and the Americans and the whole West to look at our education with fresh eyes This is one of the cases where we and the Americans have the most to learn from each other We have each a good deal to learn from the Russians, if we are not too proud Incidentally, the Russians have a good deal to learn from us too " W L SUMNER

COAL SCIENCE

THE third biennial International Conference on Coal Science was held at Valkenburg, in the Netherlands, during April 27–30 The Municipality kindly allowed the Conference to be held in the Municipal Theatre, and the greatest hospitality and interest were shown throughout by the burgomaster, F A A H Breekpot

On this occasion the number of participating countries increased to fourteen, newcomers being East Germany, Czechoslovakia, Australia and India Authors submitting papers were required to complete a form indicating, in telegraphic style, their main new conclusions and results, the methods and observations from which these were deduced, and any special limitations or assumptions involved in their interpretation This information was found by the organizers to be more helpful than the conventional summary (or on occasions the paper itself) in deciding whether a paper was acceptable , it was also useful in evaluating the conclusions of the Conference and the interrelation of papers The proceedings of this Conference will not be published as a whole , but papers will be submitted by their authors to journals of their own choosing

Discussion was unusually lively and fruitful, and a large proportion of novel work was presented In several cases widely accepted ideas were apparently undermined, though it would be premature to assess the importance of the new evidence For example a suggestion arose, from the work of S Ergun and I Wender on the X-ray scattering of vitrinites reduced with lithium in ethylene diamine, that partially reduced aromatic and/or alicyclic molecules may lead to reflexions in the angular region where the (10) and (11) reflexions of aromatic molecules occur This awaits direct experimental test, but if correct it may throw doubt upon the derivation of aromatic layer sizes in coal, for example, by Hirsch and Diamond Ergun and Wender also demonstrated an increase of layer-spacing on reduction, even in graphite

Similarly, an interpretation of data obtained on coal by high-resolution magnetic resonance spectroscopy, by J K Brown W R Ladner and N Sheppard, yielded a structural distribution of non-aromatic carbon atoms which may prove incompatible with the present consensus of opinion on the chemical structure of coal As a third example, R L Bond and D H T Spencer illustrated the inadequacy of existing interpretations of sorption data obtained with inert gases on coal and of heats of wetting of coal in polar liquids , a question thought by many to have been settled, at least in principle

These, and the other thirty-three papers presented, were grouped under four heads, as follows

Chemical Reactions of Coal

E S Hammack, H G Davis and F B Brown estimated the content of phenolic hydroxyl in vitrains by titration with sodium aminoethoxide in ethylene diamine, by trimethylsylylation and by acetylation They found reasonable agreement between these methods and noted the importance of particle size Acetylation was studied by S Delavarenne, A. Halleux and H Tschamler, who also confirmed the presence of quinone groups in coal extracts, by reductive acetylation and reduction with copper/hydrogen sulphide They observed the corresponding changes in the infra-red spectra and showed that the reduction was to a large extent reversible In both papers, tests of the quantitative accuracy of the methods by experiments on model compounds such as quinones were reported Evidence for the presence of thioether groups in coals to the extent of 15–90 per cent of the organic sulphur content was put forward by L Wnękowska The difficulty of combining all known observations on the chemical and physical nature of coal, together with the elementary analysis, in a structural model was emphasized by P H Given, who by comparison of data and experiments with atomic models had been able to find only one satisfactory pattern of structure the essential feature of this was that any pair of aromatic fused ring clusters is bound together by *two* methylene bridges

E J Greenhow and J W Smith showed that pitch can be regarded as a solution of phenolic or basic compounds of medium molecular weight in a relatively non-polar solvent , results suggested that the physical properties were influenced by intermolecular association

There were three papers on chromatographic separation of oxidation products of coal by F Micheel, J E Germain and F Valadon, and G J Lawson and S G Ward The first author had isolated small yields of aniline, anthracene, substituted anthraquinone, tetraphene and fluoranthene from air- or nitric acid-oxidized coals , the second group had identified various benzene polycarboxylic acids, and the third, malonic, succinic and *l*-tartaric acids S Landa had studied hydrogenation of model substances, montan wax and humic acids extracted from brown-coal, with tungsten and molybdenum sulphide catalysts Hydrocarbons with two to three fused aromatic rings and side-chains were found among the products from treatment of the humic acids

Ultra-fine Structure of Coals and Chars

M Węclewska discussed the influence of sorption on coals of organic vapours on their elasticity, and the consequent dimensional changes S Ergun, W F Donaldson and I Breger showed that apparent changes in rank induced in coals by α-particles originating from natural impregnation by uranium differed from those caused by normal coalification processes

J L Soulé and S Durif demonstrated, by measurements of small-angle X-ray scattering, the presence in a wide range of coals of pores of sizes 22–25 A and the variation of this characteristic with temperature of carbonization , they also deduced absolute values of specific internal surface In the carbonization temperature range 500–700° C these surface areas agreed with those estimated by P Chiche and S Prégermain from adsorption of water and methanol vapours

Sorption of pyridine by carbonization products, their solubility in it and their swelling in various organic liquids, were studied by A Ladam and P Payen Important changes were indicated in the region 400–500° C S J Gregg and M I Pope had studied the effect, on the electrical conductivity of coal artefacts, of pressure and of exposure to atmospheres of various humidities J J Kipling and R B Wilson, from a study of the sorption of gases and vapours on chars prepared by carbonizing synthetic polymers, demonstrated the presence of microcapillaries of 5–10 A diameter, molecular sieve properties of the structure, and the effect of steam activation in opening up this structure A Cameron and W O Stacey combined measurements of internal surface area, apparent density and measurement of internal volume with the porosimeter to demonstrate the presence of two distinct pore systems in chars prepared from brown-coals The presence in 600–900° C chars of cavities of some 25 A linked by passages less than 10 A wide was inferred

Spectroscopy of Coals

There were two papers on mass spectroscopy One, by J C Robb and H W Holden, was concerned with the volatile products either volatilized or liberated by pyrolysis when coal was heated in the ion source Interesting identifications in relation to temperature range were made The other, by R I Reed and W Snedden, was chiefly concerned with the fragments produced from aromatic compounds and thus widened the background available for interpreting results with coals Electron magnetic resonance spectroscopy had been used to study coals in course of carbonization under vacuum, by J Smidt and D W van Krevelen In addition, the time of relaxation T_1 was measured as a function of temperature J Uebersfeld had applied combined nuclear and electron magnetic resonance measurements and found evidence of interaction between protons and free radicals in coals of low rank, exchange interaction in those of high rank Light spectroscopy was represented in two papers, by R A Durie and J Szewczyk and by S Ergun and J T MacCartney The first was concerned with a long wave-length absorption edge which moves into the infra-red with increasing temperature of pyrolysis The magnitude of a corresponding energy gap in the structure was discussed in relation to the graph of polynuclear aromatic structures In the other paper an attempt was made to establish specific reflectance of coals as a significant structural parameter, related to the hydrogen/carbon ratio and to the diamond and graphite structures as extremes

Carbonization

C Kroger, R Brucker, M Klatt and E Bade had studied the maceral species exinite and vitrinite by pyrolysis under high vacuum They discussed the origin of the liquid and gaseous products determined A M Wandless and G W Fenton described coking tests, on coals of 84, 85 and 87 per cent carbon content, that indicated a beneficial effect on the coke strength of the maceral inertinite as a constituent in the coal blend at the two lower levels of rank D W van Krevelen, F J Huntjens and A H Wilms presented a thorough study of strength of coke in relation to particle size of coal carbonized A D Dainton, W G Kaye and J W Phillips described the effect of macerals on volume changes in briquettes during carbonization A F Boyer and P Payen threw doubt on the interpretation of an apparent exothermic peak found in the differential thermal analysis of certain coals , they considered this to result from an increase of conductivity due to agglutination Finally in this series there was an outstanding paper by P M J Wolfs, D W van Krevelen and H I Waterman on the carbonization of synthetic polymers containing aromatic units linked by methylene bridges labelled with radioactive carbon , their fate on pyrolysis could be readily followed The course of chemical decomposition was thus related to other measurements on the polymer, for example, in a dilatometer test and a thermobalance

M. F. Kessler and V. Večeřikova reported a variety of physical and physicochemical measurements on cokes and related them to hardness and reactivity. J. H. Ehretsmann and R. C. Seymour had studied the gaseous products and thermochemistry of the formation and decomposition of surface oxides on charcoals. H. Guérin and M. Bastick demonstrated the importance of microporosity during gasification of coke between 800° and 1,000° C. C. Heuchamps, L. Bonnetain, X. Duval and M. Letort showed that the apparent energy of activation of the combustion of graphite varied with temperature and extent of combustion, and was a complex function of heterogeneity, porous structure, impurities and reaction mechanism.

It is appropriate after three successive occasions when the burden of organization has largely been borne by the Dutch State Mines to add an appreciation of the magnificent arrangements made by the scientific and administrative staff of that body. The never failing resourcefulness of Mr. W. J. R. Berkx in all aspects is especially worthy of mention. The moving spirit behind these conferences has been the president, Prof. D. W. van Krevelen, and it must be recorded with regret that he has now resigned the presidency in view of his pending transfer from the coal to the plastics industry. To mark the occasion, tributes were paid at the end of the Conference by R. Loison, I. G. C. Dryden and M.-Th. Mackowsky on behalf of the French-, English- and German-speaking sections of the audience. Prof. van Krevelen's impact on coal science has occurred only within the past ten years; yet, owing to the original and prodigious output of his research teams, he has left nothing unchanged. The Conference wished him every success in his new field of endeavour.

I. G. C. DRYDEN

CURRENT RESEARCH ON NOISE

It is only within recent years that acoustic noise, once studied simply for its effect on hearing and annoyance, has proved important in physical systems. Noise has long been a source of annoyance; its effects on working efficiency have been clear when it has interfered with speech communication, less clear in causing fatigue; and for years it has been realized that continued excessive noise can cause permanent deterioration of hearing—'boilermaker's deafness' has long been known.

These effects are still with us, in intensified form, since with the increased power of machines to-day, noise—as a by-product of this power—is increasing also. For this reason, the physical aspects of noise have come to the fore. The intense fluctuating pressures in the noise field near a jet engine can fatigue and fracture the structure of the aircraft. The forces on a missile flying through rough air may consist largely of random constituents, which need to be analysed in some detail to determine whether any frequencies are present which may damage the equipment in the missile. Such analysis is, of course, similar to that used in many other fields, such as radar; and thus acoustic noise problems find their counterparts in other studies.

These different aspects of noise were explored recently in two symposia held by the Acoustics Group of the Physical Society. The first, "Recent Studies of Noise Problems", was held at the Imperial College of Science and Technology, London, on March 24, with four papers on psycho-acoustic problems, and two on physical acoustics.

Human Response to Noise

The general effect of the first group of papers, curiously, was that work in many aspects of the subject culminated some five years ago in the United States, and little advance has been made since. This was particularly true of the account of noise and hearing loss given by Prof. W. Burns (Charing Cross Hospital Medical School). This subject is still heavily in debt to the classic report (*Z24-X-2*) of the American Standards Association, and little more has been learnt about safe noise-levels. However, work is continuing on the effect of age on normal hearing; this will give a better 'base-line' for the estimation of hearing damage, and is a subject on which the American report was not very satisfactory.

Procedures for evaluation of the loudness of a complex sound, however, have progressed very little in any country. This was discussed by Mr. N. Fleming and Mr. D. W. Robinson (National Physical Laboratory). The National Physical Laboratory equal-loudness contours remain unchallenged, but they are for pure tones only. The various ways of dividing and weighting the spectrum, in order to calculate loudness, do not seem very productive; while annoyance is a factor even harder to measure objectively.

Much of this difficulty may be due to the fact that pure tones have in the past been considered of major importance. But as speech, and even music, are in effect successions of transients, many noises should be considered in the same way; and a study of the aural effects of transients may be a more fruitful approach.

The point was, however, made by Mr. Fleming that the multiplicity of criteria in American psycho-acoustic studies may not be needed. He pointed out the equivalence between the 'equal-annoyance' contours for community noise, and the readings of representative noises on the *A* weighting of the sound-level meter. The *A* weighting is a valuable one for many approximate loudness studies; it is frequently used on the European continent in traffic-noise problems.

Further points on community reaction to noise were dealt with by Mr. H. J. Purkis (Building Research Station). The techniques for evaluating the annoyance of different types of noise, developed in America some years ago, still appear generally valid, although some alterations to suit the differing susceptibilities of English communities are needed. It is hoped to collate several case histories of noise annoyance, with the view of obtaining more applicable data.

Dr. D. E. Broadbent (Medical Research Council) spoke on the effects of noise on working efficiency. This is a field in which it is most difficult to obtain conclusive results. A pattern is, however, beginning to emerge, connected with the effect of noise in interrupting attention; noise often seems to interfere with tasks necessitating short-term memory. An overall level of 90 db. appears critical, and it is found that, whatever may be the effect on efficiency at work, noise increases, for example, wastage rate, and number of mistakes

Physical Acoustics

Two papers on physical noise problems were presented Mr D M A Mercer (University of Southampton) dealt with the difficulties inherent in obtaining accurate measurements of aircraft noise Such factors as ground reflexions, size and behaviour of source can cause errors of a few decibels , comparisons of, for example, the performance of jet silencing devices may be quite misleading if these precautions are not taken

Diesel engine noise was discussed by Dr A E W Austen and Dr D Priede (C A V , Ltd) Speed and swept volume have been related to sound output , there is little variation with load, due to the characteristics of the diesel engine A quite thorough survey has been made of the vibration of different surfaces of the engine and their effects as noise producers, and sound-levels calculated from these are consistent with measured noise-levels

Aspects of Noise Analysis

The second symposium, on "New Techniques in the Analysis of Noise and Vibration", was held in the Physics Department of the University of Southampton, as a joint meeting with the Institute of Physics The attendance of about 150, drawn from diverse fields of physics, engineering and electronics, indicated the considerable interest in the analysis of 'noise in the widest sense' The emphasis was on new and projected techniques , standard bandpass filtering methods received little attention

The meeting was opened by Mr R A Eades (Signals Research and Development Establishment, Christchurch), who described the speech spectrograph, an instrument capable of examining and analysing short samples of sounds, and presenting the analysis in a manner similar to that of the visible-speech techniques Mr Eades made the important point that, in much of this work, bandpass filters with sharp cut-offs are not desirable, due to the 'ringing' they give , the lowered frequency discrimination of a filter of Gaussian or tuned-circuit characteristics is amply repaid by freedom from ringing

Mr G J Herring (Royal Aircraft Establishment, Farnborough) described an analogue-to-digital converter which converted a fluctuating voltage into an input suitable for a *Pegasus* digital computer The computer could then be used to make an analysis of the input wave-form This method was developed because purely analogue methods had proved unsatisfactory This paper, and the previous one, led to considerable discussion , it was clear that the problem of analysis of random wave-forms was important to many workers One point, however, was that the distinction between wave-forms with and without a periodic component—a difference important to the statistician —was not always made clear , with consequences perhaps of unnecessary difficulties in many analyses

Mr D M A Mercer (University of Southampton) emphasized the practical point that, in any analysis, frequency discrimination, stability of estimates and ease of computing were all linked, and could not all be maximized at once, great care was needed in the planning stages of an analysis Cross-correlation techniques were often able to give results unobtainable by straightforward methods

Dr G M Jenkins (Imperial College of Science and Technology, London) discussed the statistical implications of obtaining a spectrum via an autocorrelogram It is desirable to examine the autocorrelogram itself before the Fourier transform process , in any event, some modification to it is often desirable, to obtain a more stable spectrum, but in addition much information is often available at this stage , and different applicable statistical criteria were described

The ensuing discussion demonstrated much interest in the use of axis-crossings of a random function Presumably there is a major theoretical breakthrough to be looked for on this topic , but apart from this, theoretical and experimental studies demonstrate that axis-crossings carry most of the information of a wave-form (apart from magnitude, of course) The limitations of the method, however, are not yet known

The concluding impression of the symposium appeared to be twofold first, that 'noise in the widest sense' is a subject of considerable interest, and secondly, that there often appeared to be a considerable gap between the theoretical studies, and the work of those concerned with practical noise and vibration analysis This leads, at best, to correct analyses obtained with unnecessary difficulty, and at worst, analyses which are meaningless Closing of this gap would be of benefit to all concerned

DERWENT M A MERCER

BIOSYNTHESIS AND SECRETION OF ADRENOCORTICAL STEROIDS

AT a symposium held on February 14, the Biochemical Society gathered together a group of investigators who described their own work and that of others on various aspects of the biogenesis of the adrenocortical hormones In an introductory paper, I E Bush described the chemical nature of the steroids under discussion and the application of various types of chromatographic procedures to the separation and identification of these substances An important feature of steroid chromatography is the very large number of possible compounds and the danger of wrong identification if chromatographic properties are relied upon to the exclusion of others This danger may be diminished by the use of numerous microchemical and spectrophotometric techniques The former include acetylation or oxidation (notably the removal of the C-17 side chain) on the 10–20 μgm scale, followed by observation of the chromatographic behaviour of the product on paper Spots of steroid on paper give various well-known colour and very sensitive fluorimetric reactions On the physical side a wide range of correlations between structure and absorption bands in the infra-red region has been established Ultra-violet absorption spectra in sulphuric acid and alcoholic alkali provide useful information which, in conjunction with paper chromatography and comparison with reference substances, may provide identifications almost as reliable as those from infra-red spectra New work in Bush's laboratory has shown that useful generalizations about the behaviour of steroids in partition systems can be made using Martin's theory and the R_M function of Bate-Smith and Westall For this theoretical approach Bush has collected numerous R_F values from the literature Not all will agree with him on the reliability of these values The chromatogram tank is not yet a precision instrument

J K Grant then reviewed present knowledge of the biosynthesis of adrenocortical steroids Here there are at least three questions to be answered What is the nature of the secretion of the adrenal cortex, what sequences of reactions are involved in the syntheses of the steroids in the cortical cells and what are the mechanisms of these reactions ? Complete answers cannot be given The analysis of adrenal venous blood collected from animals and from human subjects undergoing adrenalectomy has provided direct evidence of the nature of the steroids secreted by the adrenal gland Hydrocortisone, corticosterone and aldosterone are the principal C_{21} compounds found The last of these, and a variety of others of less physiological importance, are present in trace amounts There is indirect evidence that the adrenal cortex in man secretes a substance which, in contrast with aldosterone, promotes the excretion of sodium A new steroid (3β 16α-dihydroxy-5α-pregnan-20-one), which produces this effect in rats, has recently been isolated by Wettstein from the adrenal glands of swine There is also evidence that the adrenal gland secretes androgenic and œstrogenic steroids

Application of a variety of techniques has clearly established that adrenocortical steroids may be formed in the gland from acetate or cholesterol by formation and subsequent hydroxylation of progesterone An outstanding question of major interest is the possibility of alternative pathways to those originally proposed These alternatives are concerned with the order in which the hydroxylations of the key intermediate progesterone proceed, with the possibility that cholesterol is not an obligatory intermediate in hormone formation, and with the direct transformation of cholesterol to C_{19} steroids Hydroxylations commonly occur at C-17, C-21 and C-11β in that order It has been shown beyond reasonable doubt that a C-21 hydroxy steroid cannot undergo hydroxylation at C-17 Grant has, however, demonstrated that 11β-hydroxylation of progesterone can proceed in good yield Hydrocortisone may then be formed from 11β-hydroxyprogesterone but at rates too slow to be of significance in normal biosynthesis This alternative pathway may, however, be important in pathological states Despite much suggestive evidence and numerous experiments with isotopically labelled compounds, it has not been possible to establish firmly the existence of alternative pathways from acetate to adrenocortical hormones which do not involve cholesterol When such pathways appear to have been demonstrated, alternative explanations of the results have been possible if the existence of different metabolic pools of adrenal cholesterol is assumed In other cases the results are unacceptable since the comparisons between the specific activities of precursors and products have been made at one point in time and not on a kinetic basis known to be essential in order to avoid misinterpretation of results Despite intensive study, the mechanism of steroid hydroxylation has not been elucidated Molecular oxygen and reduced triphosphopyridine nucleotide are essential It has not been possible to confirm that a transhydrogenase is involved in the formation of reduced triphosphopyridine nucleotide It has been suggested that the reduced nucleotide is required for the reduction of an oxygen activating or transferring enzyme containing a heavy metal, but proof is lacking There are, however, indications that the 11β-hydroxylating enzyme system located in the mitochondria is complex The observation that 2-methyl-1 2-bis-(3-pyridyl)-1-propanone (*SU* 4885) appears to be a specific inhibitor of 11β-hydroxylation *in vivo* and *in vitro* has aroused considerable interest

Adrenal glands of the rat, ox and man have been most extensively studied The anatomy and histology of these glands were described by T Symington He directed attention to two features which have not until recently received adequate attention from biochemists the unusual musculature of the adrenal veins which may, by restricting blood flow through the gland, influence steroid biosynthesis, and the marked differences in histology between the ruminant and non-ruminant adrenal cortex The fascicularis and reticularis zones, readily distinguished in non-ruminants, are not distinguished in the ruminant In the ox, which is typical of the ruminants, a broad zone of 'compact' cells fills the cortex from the medulla to the prominent glomerulosa beneath the capsule In man, the fasciculata zone of variable width is filled with lipid-laden 'clear' cells and lies between the reticularis zone of 'compact' cells and the glomerulosa, which is very irregular, forming islands under the capsule so that glomerulosa cells are absent from some sections The ox adrenal gland is for this reason a more satisfactory object than the human gland for the *in vitro* study of the synthesis of aldosterone which appears to occur in glomerulosa cells The morphology and histochemistry of 'clear' and 'compact' cells and the influence of corticotrophin thereon have been studied in Symington's laboratory using glands removed surgically in two stages for the treatment of breast cancer The use of these fresh glands has also permitted the study of enzyme reactions involved in steroid biosynthesis These biochemical studies and in addition the results of analysis of adrenal venous blood obtained at the time of adrenalectomy have been correlated with the morphological and histochemical observations It would appear from the results obtained that 'clear' cells of the fasciculata zone may function as stores of hormone precursor, and that the 'compact' cells of the reticularis zone, far from being the senescent cells described by others, may be the site of active hormone biosynthesis 'Clear' cells are converted to 'compact' cells under the influence of corticotrophin, which stimulates corticosteroid secretion, influencing various steps in the sequence of biosynthetic reactions Studies with the electron microscope in Glasgow have revealed important differences between the 'clear' and 'compact' cells, the most striking features of which are the microvilli, which form extensions of the cell membrane running out into the intercellular spaces The function of the microvilli is unknown, but it is interesting to speculate that they may be concerned with secretory processes

P J Ayres described the relation of steroid secretion to the histological zones of the adrenal cortex, with particular reference to the evidence which he has obtained in collaboration with Dr and Mrs Tait that aldosterone is synthesized and secreted by the cells of the glomerulosa zone. This work developed out of early observations on the rat; these supported the view that a steroid active in electrolyte metabolism was secreted by the glomerulosa zone, relatively independent of the pituitary but influenced by electrolyte intake. Further indirect evidence followed the isolation of the steroid concerned, aldosterone, from whole adrenal extract by the Taits in 1952. It was possible to show that aldosterone secretion, but not that of corticosterone, is diminished in rats on a low-potassium diet. Hypophysectomy has a much more pronounced effect on corticosterone than on aldosterone secretion in the rat. After this operation in dogs, the fasciculata-reticularis zone of the adrenal gland atrophies and the secretion of hydrocortisone and corticosterone falls; by contrast the glomerulosa zone and the secretion of aldosterone are unaffected. Direct evidence for the preferential production of aldosterone in the glomerulosa zone was obtained by the Taits and their collaborators by incubation of adrenal capsule strippings, to which glomerulosa cells were adhering, and of tissue from the underlying zone. In the ox the 17-hydroxylating enzyme system appears to be in the zone lying under the glomerulosa only, whereas the 18-oxidase system necessary for aldosterone synthesis is confined to the glomerulosa zone.

A remarkable feature of the adrenal cortex is its ability to synthesize all known types of steroid hormones. R. V. Short discussed the biosynthesis and secretion of sex hormones by the adrenal gland. In his laboratory, methods have been developed for the separation and determination of the major and some of the minor steroid constituents of adrenal venous blood. These have been applied to the analyses of blood collected from human subjects by A. P. M. Forrest in Glasgow, and from adult, new-born and fœtal domestic animals by Dr. Short's collaborators in Cambridge. Progesterone has been found in adrenal blood from women, cows, sheep and pigs in concentrations higher than in the peripheral blood. 17α-Hydroxyprogesterone, a steroid which is sixty times as active as progesterone in some biological assays, has been detected in the adrenal venous blood of women and cows. The interesting observation has been made that young calves secrete 20α-hydroxypregn-4-en-3-one. This disappears from the secretion some time after birth and is replaced by the 20β-epimer in the adult animal. The significance of this is unknown. There is good indirect evidence for the secretion of œstrogens by the adrenal cortex, but they must be present in human adrenal venous blood in amounts too small for detection by present methods. Four androgens have been reported in adrenal-vein blood in man. Dehydro*epi*androsterone is probably exclusively of adrenal origin, but its precursors are still uncertain. Androstenedione is undoubtedly the most biologically active adrenal androgen and it may be present in adrenal venous blood in relatively high concentration. It is remarkable that androstenedione and dehydro*epi*androsterone cannot be detected in even large samples of adrenal venous blood in cattle. 11β-Hydroxyandrostenedione is probably present in the adrenal venous blood of the cow and sheep as well as in that of the rat and cat, but this compound, in common with the other known 11-oxy C_{19} steroids, seems to possess little biological activity. These observations may be of considerable importance in veterinary medicine and cast doubts on the reports of adrenal virilism in cattle.

The amount of corticosterone and hydrocortisone secreted by the adrenal cortex is controlled by corticotrophin from the anterior lobe of the pituitary. How the pituitary obtains the information necessary to enable it to adjust the activity of the adrenal cortex to the body's requirements is a fascinating question which has recently attracted much attention. Knowledge of this matter was reviewed by Marthe Vogt. Few histologists consider the nerve supply to the adenohypophysis adequate for the control of corticotrophin secretion, and this control is therefore assumed to be humoral. It has been shown that substances such as adrenaline, which may be carried by the systemic blood, can promote the release of corticotrophin by the pituitary. There is also much evidence in support of the view that a stressing stimulus results in nervous activity in the hypothalamus which elaborates a 'corticotrophin-releasing factor'. This is carried by a 'portal' circulation to the anterior lobe, where it stimulates corticotrophin secretion. The original suggestion that the corticotrophin-releasing factor is identical with vasopressin has been modified by the independent observations of Saffran and Guillemin, who now propose that it is a polypeptide similar to but different from vasopressin. The purified material is active *in vitro* in nanogram amounts, and microgram quantities produce a similar effect on the rat pituitary stores of corticotrophin or on blood corticosteroids as severe stress. The active material contains seven of the eight amino-acids of lysine-vasopressin and, in addition, serine and histidine. Dr. Vogt also discussed the nature of stimuli which activate or inhibit hypothalamic activity. The level of corticosteroids in blood is now regarded as a contributing, but not the sole, factor accounting for the control of corticotrophin secretion in stress. Recent work suggests that the suppressing effect of high doses of corticosteroids may be on the hypothalamus rather than on the pituitary. In addition to lack of corticosteroid in the blood, afferent nervous impulses, especially if they elicit pain or worry, stimulate the release of corticotrophin, but the nature of the stimulus or stimuli which act in other forms of stress is unknown. General depressants of the brain inhibit the release of corticotrophin.

Dr. Vogt also reviewed knowledge of the control of secretion of aldosterone. This secretion is less influenced by corticotrophin than that of the glucocorticoids. Farrell has, however, recently found that certain preparations of corticotrophin increased aldosterone secretion in the decerebrate, hypophysectomized dog, but satisfactory evidence for the existence of a specific pituitary hormone which influences aldosterone secretion is lacking. The role of such a hormone would be limited, since increased aldosterone secretion in the hypophysectomized dog has been obtained with a variety of stimuli. Experiments in Dr. Vogt's laboratory have demonstrated the rapid and reversible response of aldosterone secretion in the dog to expansion and contraction of the intravascular volume. Infusion of blood decreases, whereas hæmorrhage increases, the secretion of aldosterone. The former effect was less easily elicited than the latter.

In the final paper, N. Saba dealt with the mode of action of corticotrophin from the biochemical point of view. He referred to the observations of Hechter that corticotrophin acts on the conversion of cholesterol to pregnenolone and the later independent work of Heard and Grant on the stimulation of

11-hydroxylation by the trophic hormone. Saba's results obtained in collaboration with Hechter suggest that corticotrophin influences the spatial relationships of enzymes involved in the biosynthesis of adrenocortical steroids. More recent work by others has revealed an effect of corticotrophin on enzyme systems which effects the reduction of triphosphopyridine nucleotide. The requirement for reduced triphosphopyridine nucleotide for steroid hydroxylation has already been referred to. If this is an important effect of corticotrophin it is difficult to relate it to the specificity of action of this hormone.

J. K. Grant

EDUCATION IN THE UNITED STATES (1957–58)

Education in the United States of America is based on three fundamental concepts: that the primary responsibility for public education rests with the States; that every person has an equal right to educational opportunities; and that educated citizens are essential to freedom and human welfare. Working within these concepts during 1957–58 the United States made further progress towards its goal of improving education for all*.

Evidence of progress is found in the increasing educational attainment of the population. The number of school years completed by the average adult 25 years of age and over increased from 9·3 in 1950 to 10·6 years in 1957. The group 25–29 years had completed 12·3 years of schooling, while the group older than 65 had completed only 8·3 years.

Although education is a State responsibility, no State administers its schools directly. Laws have been enacted in each State dividing the territory of the State into local school administrative units commonly termed school districts. The powers of local district school boards to establish and maintain schools are prescribed by State law, but permit exercise of local initiative in exceeding minimum educational standards required by the State. Each State has its own department of education, which exercises controls and provides specialized services to assist local school districts in conducting the State programme of education.

At the beginning of the school year there were 1,152,500 instruction rooms in full-time public elementary and secondary schools; an additional 142,300 rooms were needed to relieve over-crowding and to replace unsatisfactory facilities. About 70,500 instruction rooms were scheduled to be built during the year. About 61,000 rooms will be needed to accommodate next year's enrolment increase and to replace rooms that will probably be abandoned.

Almost one-third of all pupils enrolled in the public elementary and secondary schools are transported to and from school at public expense. During 1955–56, more than 10 million pupils were transported. In most States pupils must live 1½ miles or more from the school to be eligible for transportation for which the State helps to pay the cost.

Institutions of higher education classified by type of support and control are of two general types—publicly controlled and privately controlled. One-third of the approximately 1,900 higher institutions are publicly controlled and supported by public or government agencies; two-thirds are privately controlled and supported by individuals or ecclesiastic, philanthropic and other groups. The State exercises little control over institutions of higher education, even those supported by public funds, and consequently both types of institution operate with a high degree of autonomy.

In 1957–58 expenditures for education in public elementary and secondary schools and in higher institutions totalled 20,000 million dollars, which was 5·5 per cent of the 1957 total national income of 358,000 million dollars. Funds to cover expenditure in public schools were provided by Federal, State and local governments.

For the fiscal year 1958 the Federal Government appropriated approximately 2,000 million dollars for educational purposes. The total included funds administered by the Office of Education and was distributed as follows: Office of Education, 7,000,000 dollars; vocational education, 40,888,412 dollars; higher education, 5,051,000 dollars; school construction and maintenance, 225,650,000 dollars; and library services, 5,000,000 dollars.

Since the States have primary responsibility for public education in the elementary and secondary schools they provide funds and authorize local school districts to provide local tax-funds for public schools. In the 1957–58 school year it is estimated that of the total revenue for public schools the Federal Government provided 4 per cent; the States, 41 per cent; and local districts, 55 per cent. In recent years the percentage from Federal and States funds has been increasing slightly.

As much as 93 per cent of local educational revenue is obtained from property taxes. Local communities use the property tax to secure funds for current operating expenses and for school construction. Some local districts also levy non-property taxes for schools, including local *per capita* taxes and taxes on wages, sales and amusements. Non-property taxes for schools produce 7 per cent of local revenue.

Total expenditure per pupil in 1957–58 averaged 431 dollars, an increase of about 7 per cent over the amount in 1955–56.

Tax revenues supply most of the funds for public institutions; private donations, student tuition and endowment supply most of the funds for private institutions. The 1957-budgets for both private and public institutions for educational and general expenditures, excluding auxiliary services, student aid and plant expansion, totalled 3,200 million dollars. Of this, students paid 950 million dollars as tuition; earnings on endowment provided 150 million dollars; private gifts, 250 million dollars.

The organization of public schools is determined by State and local authorities, but generally the basic 12-year programme is organized as an 8-year elementary and a 4-year secondary programme or a 6-year elementary and a 6-year secondary programme. Typically a 6-year secondary programme is divided into a 3-year junior and a 3-year senior high school. The most common type of school is one attended by almost all children of school age in the community, regardless of social or economic status, sex or vocational aim On all levels schools vary greatly in size, from one-room rural schools to large urban schools enrolling several thousand students Improvement of the school district organization in sparsely populated regions has resulted in a continued decrease in the number of small high-schools

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* Progress of Public Education in the U.S.A., 1957–58. (Washington, D.C.: Gov. Printing Office; available also from H.M. Stationery Office, London.)

All States provide public schools and permit students between the ages of 6 and 20 years to attend Most States have enacted compulsory attendance laws for certain age-groups The compulsory attendance ages range from 6 to 18 years, but a majority of the States require attendance between the ages of 7 and 17 years Of the total population of persons between 6 and 17 years old in October 1957, 96 5 per cent were enrolled in school At that time 93 per cent of all school-age children, generally defined as those between 5 and 17 years old, inclusive, were enrolled In elementary and secondary schools the proportion of boys and girls was about the same but in higher-education institutions men made up about two-thirds of the student body and women one-third

School enrolments increased for the thirteenth consecutive year In 1957–58, 43,135,000 persons, or about one out of every four in the population, were attending public or private schools and colleges , an increase of more than 4 per cent over 1956–57

The latest available data indicate that about one-half of the high-school graduates now go to college, about 42 per cent full time and 8 per cent part time Attendance of students at institutions of higher education is altogether voluntary Assuming that they meet admission requirements, students are free to choose the type of institution they attend—public or private, liberal arts or technical, 2-year or 4-year, and to pursue any curriculum or prepare for any profession to the extent of their abilities A student in an institution may of his own volition drop out altogether or transfer to another institution In the autumn of 1957, colleges and universities enrolled more than 3 million students, an increase of 4 per cent over the autumn 1956 enrolment, and a 43 per cent increase over the 1952 autumn enrolment The number of freshmen entering college in the autumn of 1957 represented slightly more than 30 per cent of persons in the country who were 17 years of age in 1956 About 58 per cent of the students enrolled were in public institutions Enrolment in public institutions is increasing more rapidly than in private. About 800,000 of the students attending full time lived in dormitories provided by the institutions

The degree-granting colleges conferred a total of 411,000 degrees in 1957–58, 8 3 per cent more than in 1956–57 Of the total conferred, 82 8 per cent were bachelor's, 15 1 were master's and 2 1 were doctor's degrees The average cost of a year in college was between 1,500 and 2,000 dollars, and the median award in scholarship aid was less than 300 dollars

In 1957–58 between 30 and 35 million adults participated in adult education programmes sponsored by industry, labour unions, the Armed Services, farm organizations, and other groups In carrying out their programme, these groups had the co-operation of public libraries, public school systems, higher institutions, television systems and Government agencies

Extensive research is carried on by public and private agencies such as colleges and universities, State departments of education, and various philanthropic groups Their research is directed toward solving some of the problems facing education , for example, it includes further investigation of the learning process and the character and extent of individual differences State departments and local school systems direct their research primarily to solving local problems, and colleges and universities direct theirs to broader problems in education

THE PHYSICAL SOCIETY, 1958–59

THE annual general meeting of the Physical Society was held on May 21 at the Royal Institution, London, and immediately following the meeting Mr J A Ratcliffe delivered his presidential address entitled "Recent Trends in the Theory of the Ionosphere" The report of the council of the Society and the accounts and balance sheet for 1958 were adopted at the meeting and the composition of the new council to hold office for the session 1959–60 was announced

The income of the Society during 1958 exceeded expenditure by £4,581 and was mainly due to the increase in price of the Society's publications when sold to the general public which the council authorized in 1957 Notwithstanding the rise in price, sales have increased The membership rose from 2,069 to 2,136, but the increase was entirely in the student membership grade The forty-second annual exhibition of scientific instruments and apparatus was held during March 24–27 in the two halls of the Royal Horticultural Society The size of the exhibition and attendance were similar to those of the previous year The sales of the exhibition handbook and the receipts from exhibitors resulted in a satisfactory surplus of £5,905, of which £4,000 was transferred to the exhibition contingency fund and the remainder to the general income and expenditure account

The council's report refers briefly to the activities of the Society during the year and in particular to the conferences of two or three days duration which were held on various subjects in Cambridge, Durham, Malvern and Swansea The attendances were usually between 200 and 250, of which approximately half on the average were members of the Society A few research students and others were financially assisted to attend these conferences by means of a grant allotted to the Society by the Royal Society The decision to recombine the two sections of the Society's *Proceedings* was put into effect during 1958 and the volume of work published (208 original articles, 74 research notes and 21 letters to the editor) was substantially the same as in 1957 Vol 21 of the "Reports on Progress in Physics", which was published during the summer, contained nine articles, and these articles were also available for purchase separately

The informal discussions with the Institute of Physics which were begun in 1957 to consider the closer co-operation between the Institute and the Society were continued. A mutually agreed document entitled "Memorandum to Members—Proposal to Amalgamate the Institute of Physics and the Physical Society" was circulated, together with an explanatory letter from the president. A joint amalgamation committee has been set up and is now engaged in more detailed discussions.

At the annual meeting, the president, Mr. J. A. Ratcliffe, the honorary secretaries, Dr. C. G. Wynne, Dr. H. H. Hopkins and Mr. A. G. Peacock, the honorary foreign secretary, Prof. E. N. da C. Andrade, and honorary treasurer, Dr. D. A. Wright, were re-elected to serve for 1959–60. The newly elected vice-presidents were Prof. F. Llewellyn Jones and Dr. G. B. B. M. Sutherland, and the newly elected members of council Mr. D. W. Fry, Dr. V. E. Cosslett, Prof. F. C. Frank, Prof. W. E. Burcham, Dr. R. L. F. Boyd, Dr. R. A. Smith and Prof. D. H. Wilkinson.

S. WEINTROUB

SCHOOL MEALS IN ASIA AND THE FAR EAST

VARIOUS Food and Agriculture Organization conferences, as well as regional nutrition meetings convened periodically in co-operation with the World Health Organization, have emphasized the importance of supplementary feeding as a means of improving the nutrition of vulnerable groups. The First Regional Nutrition Committee in South and East Asia, which met in Baguio, the Philippines, in 1948, recommended a type of meal which could be supplied to school-children in the region. This meal pattern emphasized the use of cheap, locally available foods that would provide the children with all essential nutrients.

The Fourth Regional Nutrition Committee of the two Organizations, which met in Tokyo in 1956, considered a number of important factors relating to school feeding programmes; it recommended that the Food and Agriculture Organization should convene a school feeding seminar for countries in South and East Asia, at which the future development of school-feeding along sound lines could be discussed by appropriate country representatives.

Much of the Food and Agriculture Organization's practical work in school-feeding has been done in co-operation with the United Nations Children's Fund, the Organization providing the technical guidance in organizing and developing programmes based initially on dried skim milk and other supplies made available by the Fund. This Fund has become increasingly interested in the long-term development of measures to improve the nutrition of children and has recently been authorized to increase the scope of assistance which it can provide. It was agreed, therefore, that the Fund should join the Organization in convening the seminar. Because malnutrition is often a serious problem among children of pre-school age, it was also agreed that consideration would be given to this important group of the population.

The seminar was designed to bring together, from the countries concerned, workers associated with various aspects of child-feeding programmes, in particular school-feeding programmes, for consideration of the problems met in developing them and of measures needed to improve and expand them on a sound nutritional and financial basis. The Government of Japan extended an invitation for the seminar to be held in Japan, and it was held in International House, Tokyo, during November 10–19, 1958. The seminar was attended by delegates from twelve countries in the region, as well as by representatives from the World Health Organization, International Co-operation Administration, and Co-operative for American Remittances to Everywhere. A report on the seminar has now been issued (H.M.S.O., 2*s*. 6*d*.).

INDUSTRIAL HEALTH IN THE POTTERIES

DURING 1956–58, four members of the factory inspectorate carried out a survey of industrial health in the pottery industry in the Stoke-on-Trent area. The survey was undertaken with the advice of the Industrial Health Advisory Committee. This Committee was set up in 1955 by the Minister of Labour and National Service to advise him on measures to further the development of industrial health services in work-places covered by the Factories Acts.

On the advice of the Committee the Minister instituted two industrial health surveys, which were to be regarded as pilot surveys. The first was of all the factories in a particular area—the town of Halifax was chosen—and the report on that survey was published in 1958. The second was a survey of a specific industry—the pottery industry.

A number of considerations led to the choice of the pottery industry. Among them was the fact that it is geographically compact, and that, although over a number of years much has been done in the industry to eliminate or reduce the known health risk, it was considered that a survey of the pottery industry would have particular interest in giving an opportunity to assess both the success of the measures so far taken and the continuing needs.

Although a survey of this kind offers no basis for comparing conditions in the pottery industry with those of other industries, it is possible to draw some comparison between present conditions in the pottery industry and those of the past. General conditions in the industry to-day are markedly different from what they were. The industry has done a great deal, particularly in the years since the end of the Second World War, to improve working conditions and to reduce the health hazards connected with pottery manufacture.

The classic industrial disease of the pottery industry was lead poisoning, due in part to the lead glazes used. By the middle 1940's the use of low-solubility or leadless glazes had become so widespread that it was considered practicable to prohibit the use of any glaze that was not either leadless or of low solubility. This was not an easy requirement for all firms to comply with, and the glazed tile industry was faced with a particularly difficult problem. Intensive research enabled all firms to be in a position to comply with the requirement when it became law. The other source of lead poisoning was the colour used in decorating the ware. Higher standards of cleanliness and improved methods of dust control have, so far, dealt with this hazard, with the satisfactory result that in recent years lead poisoning has virtually been eliminated from the industry.

Another major achievement of the industry, this time in reducing the risk of pneumoconiosis, has been the substitution of alumina for powdered flint in the placing of china for the biscuit fire. When it became clear that alumina was a satisfactory alternative, the china industry, in spite of some technical problems involved, agreed that the flint should be replaced by alumina. By 1947, when this change was made compulsory, all firms in the industry had in fact changed over.

Work on the control of dust in the making processes, where there is a health hazard from pneumoconiosis, is continuing. For some years the British Ceramic Research Association has been working on the dust problems of the industry, and has done much valuable research work into the behaviour and control of dust given off in certain processes. The Research Association has already designed dust-control plant for the processes of towing and hollow-ware fettling which is proving most effective. Work is in progress on the control of dust in the dust tile-making processes, and to determine the most suitable material for workers' overalls where there is need to protect them against dust.

To provide a continuing forum for discussion of the health and safety problems of the industry, the Chief Inspector of Factories in 1956 appointed a Joint Standing Committee of the Pottery Industry. With the help of the British Ceramic Research Association, it has published an advisory booklet on dust-extraction in the pottery industry. It has also directed the attention of industry to the dangers inherent in the use of hydrofluoric acid in cleaning gold, encouraging the use of other methods which it has made known.

The aim of the survey was to present an objective picture of existing conditions in the industry and to indicate outstanding problems. The visits made by the inspectors have been followed up by action to secure improvements. The work that requires to be done in order to deal with outstanding problems is under examination by the Joint Standing Committee (H.M.S.O., 5*s*.).

DEVELOPMENTS IN TRAINING

A SERIES of five papers on training were given at the Polytechnic, Regent Street, to an audience of two hundred directors and industrial executives during January and February, 1957. They have now been reprinted and form a valuable addition to the scanty information available for those concerned with all aspects of training in industry*.

The first, by Prof. J. Z. Young, deals with the fundamental aspects of learning by drawing on biological studies of organisms at all levels of complexity. Developing the importance of perception in learning, W. D. Seymour, of the Department of Engineering Production in the University of Birmingham, produces evidence to show that carefully devised training procedures for manual skills which take account of recent findings will usually halve the normal learning period. In the third lecture, Mrs. W. Raphael, assistant director of the National Institute of Industrial Psychology, describes the in-plant training being carried out in seven European countries and shows that the training provided for operatives exists largely in name only. F. A. Heller, head of the Department of Management Studies at the Polytechnic, shows how the development of managerial skills can be approached from the same biological and analytical points of view as any other skill training. Like other lectures in the series, he pays special attention to the methods rather than to the content of training programmes. The fifth lecture was given by S. D. M. King, director of Organization and Training, Ltd., who used case-studies to illustrate the importance of relating training to a carefully devised policy at all levels of an organization.

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* New Developments in Training: Five Studies in the Efficient Communication of Skills. Edited by Frank A. Heller. (New Development Series No. 3.) Pp. 80. (London: Polytechnic Management Association, 1959.) 5*s*.

ERGONOMICS

THE development of modern industry with the substitution of mechanization for craftsmanship has brought new problems; the machine has reached the point where it is no longer the limiting factor in production and this in turn is imposing new stresses and strains on the operator, who can no longer be left to get along as best he can. That this was beginning to happen began to be realized about fifty years ago, and early developments in fitting the job to the man, like the motion study of Gilbreth, were part of scientific management for increasing production through reduction of fatigue. Men of the biological sciences began to become aware that people at work were worthy of study and that remarkably little was known about their capabilities and aspirations.

It took the added stress of two world wars to stimulate any real interest. A start was made in the First World War when groups of physiologists and psychologists such as the Industrial Fatigue Research Board in the United Kingdom started work. Between the wars progress was slow, perhaps because a general labour surplus removed a demand for maximum economy in use of labour; but during and since the Second World War the research effort has been vastly intensified. Much of it gained its initial impetus from the armed forces and has, particularly in the United States, continued to be supported by them. In other countries research has been much more directed towards solving industrial problems, as typified by that done by work physiologists in Sweden and Germany.

The fragmentation of the subject into a number of disciplines independently studying human work could not continue indefinitely, and the first fusion occurred in the United Kingdom in 1949 with the formation of an interdisciplinary society and the coining of the term 'ergonomics' to cover the study of human work. Although the British society attracted adherents from all over the world it soon became clear that a truly international meeting was needed. The initiative was taken by the European Productivity Agency in the form of Project 335, the final aim of which is a tripartite international conference of scientists, employers and employees. As a preparation for this, two preliminary steps were taken. The first was to send a mission to the United States to report on the situation there, and the second was to hold a technical seminar to assemble information on progress in Europe. A report has now been issued, part one of which contains the report of the mission and part two a report on the seminar*. The tripartite conference has still to take place.

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* "Fitting the Job to the Worker. A Survey of American and European Working Conditions in Industry" (Paris, O.E.E.C., 14s.).

AN OCEANOGRAPHIC SURVEY OF THE ROSS SEA

By J. S. BULLIVANT

New Zealand Oceanographic Institute, Department of Scientific and Industrial Research, Wellington, New Zealand

IN January 1959 an oceanographic survey of the Ross Sea was carried out by members of the New Zealand Oceanographic Institute, from the New Zealand Antarctic Supply Ship H.M.N.Z.S. *Endeavour*.

The route taken by the *Endeavour* and the distribution of the twenty-four stations occupied are shown in Fig. 1. A brief station list is also included, particularly for the information of workers planning investigations in the area in the near future.

The aim of the survey was to investigate the hydrology, the benthic fauna and the marine sediments in the area.

The routine procedure at each station was to lower a bathythermograph (275 m.) and a cast of reversing bottles, make a vertical plankton haul from near the bottom to the top, collect phytoplankton, make three lowerings with a twin orange-peel grab sampler and collect epifauna from the bottom with a trawl. The grab sampler consisted of two modified four-blade orange-peel grabs, each having a bucket capacity of 24·5 litres, suspended one at each end of a 4-ft. bar.

In addition to these routine observations, surface water samples from stations *A*466 and *A*470 and a bottom water sample from *A*470 were obtained for determination of carbon-14 activity in order to study water movements in the Ross Sea and under the Ross Ice Shelf.

An underwater-camera and a bottom trawl were used at three stations (*A*468, *A*469 and *A*471) near Ross Island, to sample three different types of bottom community. Some of the photographs

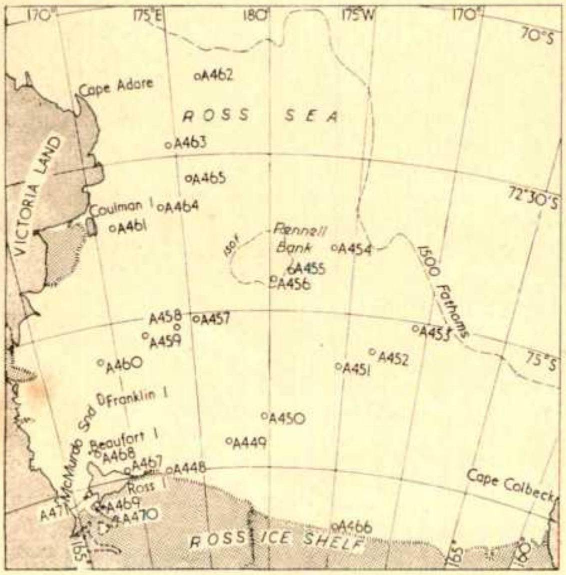

Fig. 1. Ross Sea, Antarctica, showing stations occupied from H.M.N.Z.S. *Endeavour*

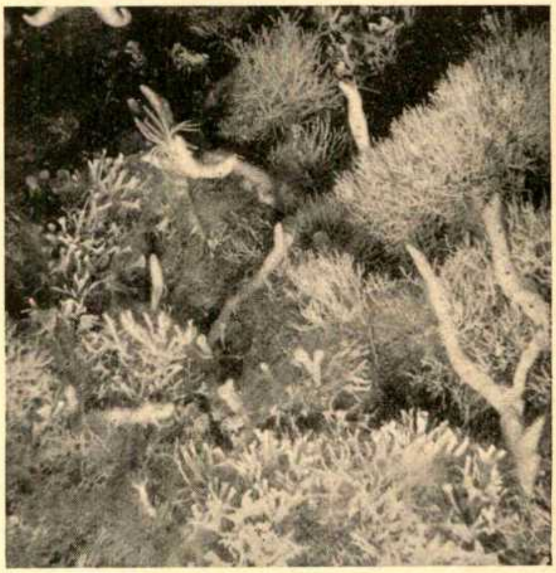

Fig. 2. Bottom photograph from station *A*468; sponges, coelenterates and bryozoans predominate. Note crinoid top left. (Depth, 110 m.; foreground, 0·75 m. wide; depth of field, 1 m.)

Table 1 LIST OF STATIONS OCCUPIED FROM H M N Z S *Endeavour* IN THE ROSS SEA

N Z O I Station No	Position	Date	Provisional depth (m)	Nature of bottom	Serial hydrological observations to (m)	Trawls	Grabs	Phyto-plankton	Plankton	Other
*A*448	77° 27′ S , 172° 22′ E	10 1 59	752	mud	705	×	×	×	×	
*A*449	77° 05′ S , 177° 12′ E	11 1 59	362	mud	265	×	×	×	×	
*A*450	76° 42′ S , 179° 44′ E	11 1 59	472–318	muddy sand	265	×	×	×	×	
*A*451	76° 00′ S , 175° 25′ W	12 1 59	523	gritty mud	515	×	×	×	×	
*A*452	75° 35′ S , 173° 18′ W	12 1 59	1,280	yellow-brown mud	1,300	—	×	×	×	
*A*453	75° 09 S , 171° 00′ W	13 1 59	2,195	yellow-brown mud	1,400	—	×	×	×	
*A*454	73° 56′ S , 176° 30′ W	14 1 59	914–828	rocks	255	×	—	×	×	
*A*455	74° 22′ S , 178° 35′ W	15 1 59	322–340	stones, muddy sand	320	×	×	×	×	
*A*456	74° 30′ S , 179° 40′ W	15 1 59	238–201	stones, gritty mud	180	×	×	×	×	fishing line
*A*457	75° 02′ S , 175° 50′ E	16 1 59	315–342	mud	312	×	×	×	×	
*A*458	75° 10′ S , 174° 00′ E	16 1 59	461–486	muddy sand	436	—	×	×	×	corer
*A*459	75° 17′ S , 172° 20′ E	16 1 59	534–549	soft mud	510	×	×	×	×	corer
*A*460	75° 38′ S , 168° 32′ E	17 1 59	415–430	gritty mud	395	×	×	×	×	corer
*A*461	73° 32′ S , 171° 22′ E	18 1 59	578–567	sandy mud	555	×	×	×	×	corer
*A*462	71° 15′ S , 176° 30′ E	20 1 59	1,831–2,381	gritty mud	1,750	—	—	×	×	
*A*463	72° 20′ S , 174° 50′ E	21 1 59	468–465	barnacle plates	435	×	×	×	×	
*A*464	73° 20′ S , 174° 00′ E	22 1 59	369–384	sand pebbles	345	×	×	×	—	
*A*465	72° 55′ S , 175° 30′ E	22 1 59	399	barnacle plates	375	×	×	×	—	
*A*466	78° 26′ S , 174° 50′ W	24 1 59	569	mud	570	×	×	×	×	corer ^{14}C sample
*A*467	77° 25′ S , 169° 28′ E	26 1 59	88–183	rocks	—	×	—	—	×	
*A*468	76° 59′ S , 167° 36′ E	26 1 59	110	—	—	×	—	—	—	camera
*A*469	77° 50′ S , 166° 33′ E	29 1 59	64	gritty mud, spicules	—	—	×	×	×	camera
*A*470	77° 50′ S , 166° 30′ E	4 2 59	377	muddy sand	365	—	×	—	×	^{14}C samples
*A*471	77° 37′ S , 166° 20′ E	6 2 59	165–69	—	—	×	—	—	—	camera

revealed a surprisingly dense epifauna, dominated by sponges and Bryozoa (Fig 2)

A gravity corer was used at stations *A*458, *A*459, *A*460, *A*461 and *A*466, short cores were secured

Hourly surface water samples were taken on passage out of McMurdo Sound, and continuous surface temperatures were recorded during the greater part of the cruise

Of particular interest was the discovery of large deposits of calcareous barnacle plates The plates were found sparsely distributed over the whole of the Ross Sea, but at stations *A*463 and *A*465 in approximately 460 m and 400 m, respectively, these plates, together with scattered rocks on which a live barnacle was growing, formed the bulk of the bottom deposit The deposit also contained a small percentage of the calcareous remains of molluscs, bryozoans and corals, but as far as penetrated by the grabs and trawl was entirely free of mud or sand The living and dead barnacles belong to the genus *Hexelasma* Estimates of the age of the barnacle plates are to be made from determinations of their carbon-14 activity

The biological material collected is a substantial addition to that already available from Antarctic waters

Results of the survey will be published by the New Zealand Department of Scientific and Industrial Research

The wholehearted support the expedition received from the commanding officer and ship's company of H M N Z S *Endeavour* is gratefully acknowledged

CHANGE OF COSMIC RAYS IN SPACE

By PROF H V NEHER

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THE advent of space rockets now makes possible direct measurements on quantities that have heretofore suffered from the interference of the Earth, its atmosphere or its magnetic field Among these are measurements on cosmic rays The absorption of the radiation in the Earth's atmosphere and the analysing effect of its magnetic field have, however, yielded valuable information on the total energy content and the individual particle energy From such measurements, together with a knowledge of their chemical composition, one can deduce the intensity or number of primaries in space When this is done, using results collected over a period of years obtained with balloons at various latitudes, one finds surprisingly large time variations in the numbers of primary particles In what follows we discuss what such measurements have so far disclosed about the absolute intensity and how it varies with time Some preliminary measurements have already been made in rockets, and further measurements, giving more complete checks on these calculations, will undoubtedly come in the future

A brief note concerning these large changes, based on data taken in 1954 and 1957, has already been published[1] We wish here to present two additional methods of arriving at the numbers of primary particles in 1954 together with new results taken near the north geomagnetic pole in the summer of 1958 when the intensity there was even lower than in 1957

The period 1954–58, when solar activity went from a minimum to a maximum of activity, provided

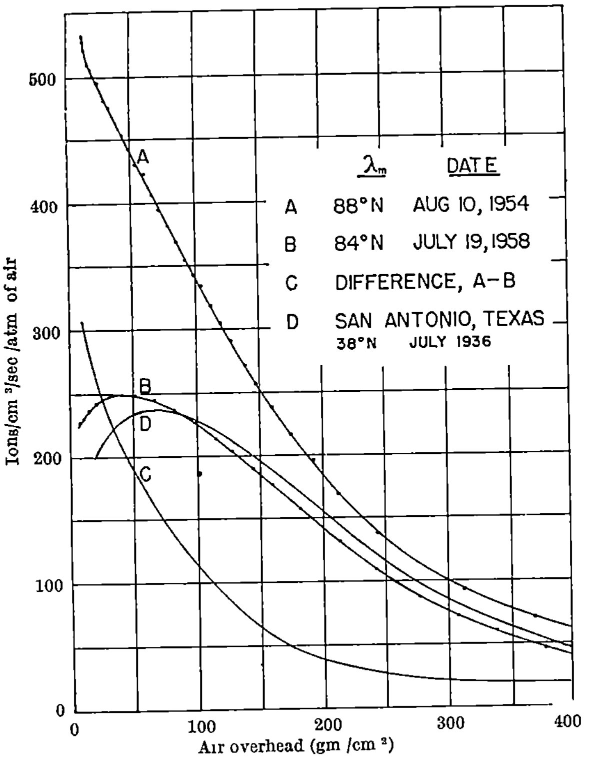

Fig 1 Curves A and B show the extremes of the ionization so far measured with balloons near the north geomagnetic pole Curve A represents data taken at the solar minimum of 1954, while curve B represents the situation near the solar maximum of 1958 The absorption in the atmosphere of the particles present in 1954 but which were absent in 1958 is given by curve C

an excellent opportunity to study the changes produced in cosmic rays Fig 1 shows how large these changes have been near the north geomagnetic pole The behaviour of curve A was typical of the curves from five similar balloon flights[2] made with ionization chambers in July and August 1954 All five records showed the same turn-up of the ionization curve at about 15 gm cm $^{-2}$ It was shown in ref 2 that the behaviour of curve A at low pressures was consistent with the absorption of low-energy particles and that the turn-up was probably due to the absorption of protons with energies down to at least 150 MeV

By 1958, the character of the radiation at the pole was radically different The largest decrease occurred in the year 1956-57[1] As shown by curve B, the ionization at high altitudes was less than half its value in 1954 In fact, the area under curve B is about 3 per cent less than the area under the curves taken in 1936 at San Antonio, Texas[3] (geomag lat 38° N) It should be remarked that we feel confident that a direct comparison can be made between these years, for we not only have instruments which we have compared through the years but we have also checked their absolute calibration by using standard capacitors

Our first method of estimating the number of primaries in 1954 is to calculate the number causing the difference between 1954 and 1958 and then adding to this the number present in 1958 To arrive at this latter figure we note that due to the nearly equal areas under curves B and D of Fig 1 and to the similarity of shape, the number of primaries must be about the same Taking the difference in area at the lower pressures and assuming a mean energy of 3 BeV per particle causing this difference, we find that the number of primaries involved is approximately 0 007 cm $^{-2}$ sec $^{-1}$ sterad $^{-1}$ Previous calculations[4] have shown that the number of primaries present at San Antonio in 1936 was 0 040 cm $^{-2}$ sec $^{-1}$ sterad $^{-1}$ This number is consistent with the measurements of MacDonald[5] at the equator, together with the increase in energy brought in by the primaries as one goes from the equator to 38° N We thus find that the number of primaries present in 1958 near the pole was 0 047 cm $^{-2}$ sec $^{-1}$ sterad $^{-1}$

Referring now to Fig 1, curve C shows the difference between A and B and represents the absorption in the atmosphere of those particles that were present in 1954 but were absent in 1958 A Gross transformation of this difference curve shows that the major part of the area under the curve is due to particles the effect of which varies nearly linearly with thickness of atmosphere The fact that curve C has a tail that extends even to sea-level is undoubtedly due to mesons formed in the upper part of the atmosphere and especially by the higher-energy primaries that also change during a solar cycle

Ignoring the high- and low-pressure ends, the bulk of the area may be accounted for by particles with a maximum range of about 300 gm cm $^{-2}$ in air Assuming a range proportional to the energy, we may say with sufficient accuracy that the Gross transformed curve corresponds to a differential number distribution that is independent of energy

We shall here assume that 15 per cent of the primaries responsible for curve C are α-particles, 2 per cent of average $Z = 8$ and the remainder protons We find that we need protons of mean energy 0 55 BeV , α-particles of mean energy 2 2 BeV and for $Z = 8$, a mean energy of 1 2 BeV per nucleon, for each to have a mean range of 150 gm cm $^{-2}$ We then arrive at a weighted mean energy of 1 5 BeV per particle The area under curve C is 1 00 × 10^9 eV cm $^{-2}$ sec $^{-1}$ Hence the number of particles per unit of horizontal area is 0 67 cm $^{-2}$ sec $^{-1}$ Thus per unit of solid angle we have, 0 21 cm $^{-2}$ sec $^{-1}$ sterad $^{-1}$

To arrive at the total number of primaries at the pole in 1954 we add to the above the number present in 1958 We have already found this to be 0 047 cm $^{-2}$ sec $^{-1}$ sterad $^{-1}$ In this manner we find the total at the top of the atmosphere near the pole in 1954 to be 0 26 par sec $^{-2}$ sec $^{-1}$ sterad $^{-1}$

Another method of arriving at the number of particles responsible for the difference between 1954 and 1958 is to estimate the mean specific ionization per particle at the top of the atmosphere and, knowing the ionization, the number of particles immediately follows

Taking the mean energies of the protons, α-particles and average $Z = 8$ for the heavy primaries, as given above, we find that the specific ionization relative to that for a minimum ionizing particle of unit charge has the values 1 3, 5 2 and 64 respectively Using the relative abundances cited before and published curves on energy loss, we find the average specific ionization for these time-varying particles at the top of the atmosphere at the pole to be 210 ion pairs cm $^{-1}$ in air at 1 atm If $\bar{\sigma}$ is this mean specific ionization and there are J particles cm $^{-2}$ sec $^{-1}$, then the ionization, $I = \bar{\sigma}J$ Since $I = 350$ ions cm $^{-2}$ sec $^{-1}$ atm $^{-1}$ of air from Fig 1, then $J = 1$ 67 The instrument is receiving particles from a solid angle of 2π Hence the uni-directional intensity is 0 26 par cm $^{-2}$ sec $^{-1}$ sterad $^{-1}$ This method then gives a total of 0·31 par cm $^{-2}$ sec $^{-1}$ sterad $^{-1}$ at the pole in 1954.

A third method of arriving at the numbers of particles is to take the increments in the area under the ionization-depth curves for changes of latitude. This was done in 1954 from Boston to Thule, Greenland, using Bismarck as a base station to take account of temporal changes. The results of this analysis have been published[2]. These calculations gave a total of 0·24 par. cm $^{-2}$ sec $^{-1}$ sterad $^{-1}$ at the pole.

These three values, 0·26, 0·24 and 0·31, then give an average of 0·27 par. cm $^{-2}$ sec $^{-1}$ sterad $^{-1}$ at or near the north geomagnetic pole in the summer of 1954. An application of Liouville's theorem tells us that with an isotropic distribution at infinity, this was also the intensity in space at that time. The corresponding total intensity in space was then 3·1 cm $^{-2}$ sec $^{-1}$ through a sphere of unit area.

In 1958, the intensity at or near the pole was 0·047 cm $^{-2}$ sec $^{-1}$ sterad $^{-1}$ or 0·59 cm $^{-2}$ sec $^{-1}$, as discussed above. We thus arrive at the conclusion that the numbers of particles in space near the Earth, but sufficiently far removed to be free from any of its effects, changed by a factor of 5 during this period of four years. This is probably a lower limit, for we do not know how high the ionization would have gone in 1954 had our balloons gone higher.

So far, data on the number of cosmic-ray particles in space have been obtained by both the United States and the U.S.S.R. On the journey of *Pioneer IV* which went near the Moon and is presumably now in orbit around the Sun, the data at large distances gave 1·8 ± 0·3 particles cm $^{-2}$ sec $^{-1}$. (I am grateful to Prof. J. A. Van Allen for giving me this figure.) This rocket was launched on March 3, 1959. For the Russian cosmic rocket, launched on January 2, 1959, the value measured[6] was 2·3 cm $^{-2}$ sec $^{-1}$. These values are to be compared with the above calculated values using ionization chambers of 0·59 cm $^{-2}$ sec $^{-1}$ in 1958 and 3·1 cm $^{-2}$ sec $^{-1}$ in 1954.

There are at least two reasons why the values measured in these rockets at the beginning of 1959 are higher than those calculated from terrestrial measurements in the summer of 1958. (1) Cosmic-ray intensity near the orbit of the Earth appears to have reached a minimum near the summer of 1958 and had definitely started to climb[7] by January of 1959. (2) The instruments in each of the rockets were surrounded by the material of the vehicle. One would therefore expect the number of secondary particles to be an important factor. This would be especially true for the Soviet rocket, which was quite massive. To avoid the uncertainty of the contribution of surrounding matter, the detecting instrument would need to be ejected from the vehicle and remain at some distance away.

For those interested in space travel, an estimate may be made of the radiological intensity of cosmic rays in space. From Fig. 1 we see that the ionization at the pole was at least 530 ions cm $^{-3}$ sec $^{-1}$ atm $^{-1}$ of air at the highest altitude reached. In space, where the shielding effect of the Earth is missing, this number would be just doubled. In terms of radiological units we would then expect at a solar minimum to have at least 1,060 ions cm $^{-3}$ sec $^{-1}$ atm $^{-1}$ of air = 1·8 mr (milliroentgens) per hr. At the solar maximum of 1958, we found the total intensity in space across unit sphere to be 0·59 par. cm $^{-2}$ sec $^{-1}$. Assuming an average specific ionization of 200 ions cm $^{-1}$ of path in air at 1 atm., we find an ionization of 120 ions cm $^{-3}$ sec $^{-1}$ atm $^{-1}$ of air or 0·21 mr per hr.

It is to be hoped that as time progresses data from instruments in rockets will give us more definite information as to the mechanism that causes these large changes in the primary cosmic radiation.

The assistance of the Office of Naval Research in making the necessary arrangements to carry out this programme is greatly appreciated. I would also like to thank the Office of Naval Research, the Atomic Energy Commission and the National Academy of Sciences through the International Geophysical Year for financial support.

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[1] Neher, H. V., and Anderson, Hugh, *Phys. Rev.*, **109**, 608 (1958).

[2] Neher, H. V., *Phys. Rev.*, **103**, 228 (1956).

[3] Millikan, Neher and Haynes, *Phys. Rev.*, **50**, 992 (1936).

[4] Neher, H. V., *Phys. Rev.*, **83**, 649 (1951). See also Neher, H. V., "Annual Review of Nuclear Science", **8**, 217 (1958).

[5] MacDonald, F. B., *Phys. Rev.*, **109**, 1367 (1958).

[6] Vernov, S. N., Chudakov, A. Ye., Vakulov, P. V., and Logachev, Yu. I., Moscow, *Doklady Akademii Nauk SSSR*, **125**, 304 (1959).

[7] Results to be published.

STUDIES OF COAL

By STAFF OF THE BRITISH COAL UTILISATION RESEARCH ASSOCIATION

Carbonization of Coals in the Presence of Activated Charcoal

It has been reported recently by Adams *et al.*[1] that the pyrolysis products of coal, if left in contact with a hot carbonaceous surface, undergo further reactions. Experiments in our laboratories[2] have yielded further results of a similar kind with respect to the behaviour on heating of coal mixed with, or overlaid by, charcoal.

Measurements of the amount of tar-like pyrolysis products emitted on burning briquettes made from mixtures of a low-rank coal and an activated charcoal (prepared from a coal char) showed a decrease as the proportion of coal in the mixture decreased, but more markedly than was to be expected from a dilution effect. On the other hand, briquettes made from the same coal mixed with an unactivated char-coal did not show a disproportionate reduction. It thus appears that the tar-like pyrolysis products evolved during heating were cracked on the extensive surface of the activated charcoal. The surface area that would be accessible to the large molecules likely to be present in these volatile vapours would be about 200 m ^{2}/gm., whereas the accessible surface area of the unactivated char would be less than 5 m ^{2}/gm.

When mixtures of coal and activated charcoal, or beds of coal overlaid with activated charcoal, were heated in a slow stream of nitrogen, or at a reduced pressure, to about 600° C., no tarry material was formed; instead, it was possible to collect in cooled traps an almost colourless liquid. This liquid was found, by infra-red analysis, to be composed of simple organic molecules (the benzene and toluene yield was in the range 0·3–0·7 per cent of the dry coal weight, compared with 0·1 per cent from the coal alone).

Table 1 Yields of Products from the Carbonization to 600° C of a Low-rank Coal (N C B Type 902) overlaid with Activated Charcoal
(Percentages of dry coal weight)

Ratio of charcoal to coal	Acidic aqueous liquor	Tar oil		Combustible gas		Carbon dioxide	Carbon deposited in the charcoal	Total
		Total	Benzene + toluene	Total	Paraffin to hydrogen ratio			
0	9 7	10 0	0 11	7 2	1 5	3 0	0	29 9
¼	9 7	2 7	0 36	8 8	1 5	3 7	5 3	30 2
½	9 7	1 4	0 46	8 5	1 4	4 7	5 5	29 7
1	9 7	1 2	0 72	8 5	1 3	6 8	6 0	31 2

The gaseous material evolved from the bed was found to be different from that obtained from the carbonization of the coal alone and, further, it was deduced from weight balances for the system and from analysis of the charcoal after use that carbon had been deposited in the charcoal

In Table 1 are compared the results obtained from the carbonization to 600° C of a low-rank coal (N C B type 902) with those from the same coal overlaid with an activated charcoal

When smaller proportions of charcoal were used in the carbonization experiments it was found that the condensates became slightly coloured and their complexity was increased The charcoal could be used again, provided the deposited carbon from the cracking process, which reduced the effectiveness of the charcoal, was removed by oxidation, for example, with steam at about 900° C There seemed to be little doubt that to achieve the complete elimination of dark tarry material from the condensates it was necessary for the vapours of the pyrolysis products of the coal to encounter a substantial amount of carbon surface The effect reported by Adams *et al* is not as great as that which we have observed , the reduction by only 1 per cent of the amount of tarry matter formed, and the slight increase in the amount of liquor, suggest that but little carbonaceous surface was available for cracking the coal 'volatiles'

It could be concluded that if a large amount of a pre-carbonized char, sufficient to have the necessary available surface area, was overlaid upon a 'green' coal and the whole was heated, very little tar would be formed, although some benzole would be obtained together with a gas of useful calorific value

R L Bond
A M Godridge
A. R Murnaghan
D H Napier
D J Williams

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[1] *Nature*, 183, 33 (1959)

[2] Brit Coal Utilisation Res Assoc Ann Rep , 38 (1956)

Smoke Emission from Coal and Low-Temperature Chars

Work by this Association in a laboratory apparatus[1-3] has confirmed the observations of Piersol[4], afterwards verified by Adams, Games, Gregory and Pitt[5], that volatile matter is not an adequate guide for the amount of smoke produced from chars In Fig 1 it will be seen in all cases that chars prepared from a low-rank coal produce less smoke than coals with equivalent volatile matter Although Piersol[4] claimed a straight-line relation between the amount of smoke liberated under standard conditions of testing and the percentage of volatile matter in a range of coals, we did not find a direct proportionality (Fig 1) There is a general tendency for smoke emission to decrease with decreasing volatile matter, but highly caking and swelling coals tend to mask this trend McHugo, Shaw and Whittaker[6], who burnt a range of coals in a domestic appliance, observed a similar effect

We found a relation between tar-yields (Gray King assay at 600° C) and smoke emission for a number of samples, similar to that found by the Coal Research Establishment workers[5] We decided to extend the investigation into the relation between the hydrogen content of coals and their smoke emission for the following reasons

(1) Spooner[7] maintained that the tar yield of bright coals was related to their hydrogen contents Bradbury and Mott[8] therefore stated that, since tar yield and smoke emission are related, either the hydrogen content or the tar yield should serve as a guide to the amount of smoke produced We have also established a definite correlation between the tar yields (not given in this communication), and the hydrogen contents for the fuels which we examined (eighteen), the correlation coefficient being calculated as 0 93, which is found to be significant at the 0 001 level of probability

(2) Smoke is probably related in some manner to the chemical constitution of the fuel, particularly to the size and stability of the condensed aromatic ring clusters and the number of edge groups, which in turn are related to hydrogen content

(3) We have shown by statistical examination that when weight of smoke is plotted against volatile matter (Fig 1) the high-swelling coals follow a different relation from that for the low-swelling coals, the high-swelling coals producing more smoke than low-swelling coals with equivalent volatile matter

Fig 2 shows the general relation between the weights of smoke and the hydrogen contents of the coals and chars tested Both high- and low-swelling coals appear to follow the same relation

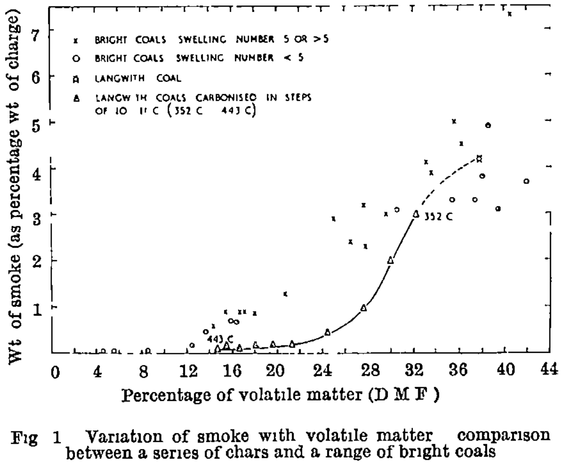

Fig 1 Variation of smoke with volatile matter comparison between a series of chars and a range of bright coals

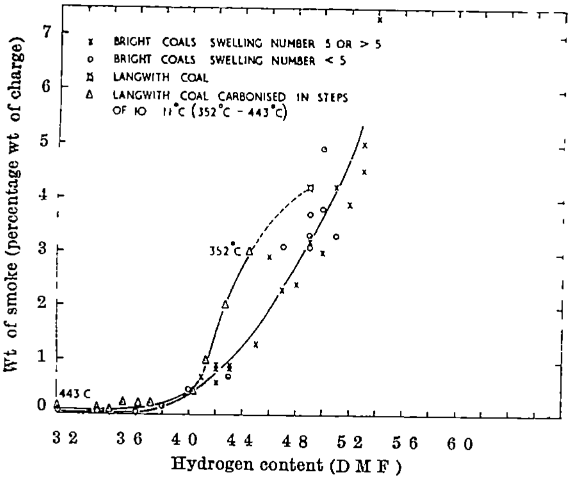

Fig 2 Variation of smoke with hydrogen content comparison between a series of chars and a range of bright coals

In Fig 2 the smoke emission from chars prepared from a low-rank coal is also plotted against their hydrogen contents and the curve obtained may be compared with that from the range of coals discussed above At the lowest carbonizing temperatures (352–382° C) there is a rapid rate of decrease in smoke emission As the carbonizing temperatures increase the rate of decrease decelerates At about 382° C (4 2 per cent hydrogen content D M F) the two curves meet Below this point the differences between the weights of smoke emitted for corresponding hydrogen values are so small they may be ignored, and for the purpose of the subsequent discussion the lower parts of the two curves may be regarded as coincident

From differential weight losses on Langwith coal[9] it is known that its pyrolysis begins about 335° C and the decomposition reaches a maximum rate at about 410° C Consequently, since chars produced at 400° C emit inappreciable amounts of smoke (Fig 2), it would seem that the low-boiling (low molecular weight) constituents which are first evolved are the main compounds responsible for smoke formation

Using infra-red techniques, Brown[10] examined a weakly caking and a strongly coking coal Between 440° and 550° C he found that hydrogen is lost by the removal of edge groups and the evaporation of small molecules followed by the loss of aromatic hydrogen and some graphitization at higher temperatures

The rank of coal[11] as well as the temperature of carbonization will affect the rate and type of decomposition and the structure of the residue These factors will obviously influence the constitution of the residue and the composition and amount of smoke evolved from a particular char during combustion The results with chars from Langwith coal may therefore be used only cautiously when coals of other rank are considered

When volatile matter is the abscissa and smoke the ordinate (Fig 1) then the curve for chars lies below that for coals, but when hydrogen content is the abscissa (Fig 2) the positions of the two curves are reversed

The explanation proposed is that although a char and a coal may yield the same volatile matter in the B S test, the constituents evolved may be quite different The coals will evolve moisture and low-molecular weight hydrocarbons which react and polymerize to form "tarry bodies"[12], whereas the chars will evolve hydrogen and other gases which ignite more easily or react together and condense less readily than those from coals Consequently, a coal with the same volatile matter as a char will produce more smoke It is not clear why a char with a hydrogen content equivalent to that of a coal yields more smoke

The laboratory work has suggested that either the tar yield or the hydrogen content provides a better indication of the amount of smoke emitted from coals than does the volatile matter Other work now in progress in these laboratories should indicate how far such relations hold for domestic open fires during ignition and steady-state combustion conditions

D FINCH

[1] Brown, R L , *J Inst Fuel* , 29, 218 (1956)
[2] Brit Coal Utilisation Res Assoc Ann Rep , 31 (1956)
[3] Finch, D , and Raftery, M M (private communication), B C U R A Information Circular No 189 (Dec 1957)
[4] Piersol, R J , Illinois State Geological Survey, Rep No 41 (1936)
[5] Adams, W N , Gaines, A F , Gregory, D H , and Pitt, G J , *Nature*, 183, 33 (1959)
[6] McHugo, J W , Shaw, W F B , and Whittaker, D , *J Inst Fuel*, 28, 318 (1955)
[7] Spooner, C E , *J Inst Fuel*, 11, 134 (1937–38)
[8] Bradbury, D J , and Mott, R A , *Fuel in Science and Practice*, 20, 100 (1941)
[9] Godridge, A M (private communication)
[10] Brown, J K , *J Chem Soc* , 5563, 752 (1955)
[11] Hirsch, P B , Conference on Science in the Use of Coal, Sheffield, A, 29 (1958)
[12] Travers, M W , *Nature*, 183, 1321 (1959)

TWO ENZYMIC MECHANISMS FOR HYDROGEN TRANSPORT BY PHENOLIC ŒSTROGENS

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ŒSTROGENIC steroids such as œstradiol-17β can mediate the enzymic transfer of hydrogen between triphosphopyridine nucleotide and diphosphopyridine nucleotide[1–3] The same enzyme concerned with this œstrogen-dependent transhydrogenation also catalyses both the reduction of these two nucleotides by œstradiol-17β, and the oxidation of their reduced forms by œstrone There is strong evidence[1,2] that, in the transhydrogenase reaction, the steroid transports hydrogen by the change steroid alcohol $\rightleftarrows$ steroid ketone

It has been suggested that this coenzymatic function of ovarian œstrogens is related to their mode of physiological action[1,2] However, powerful œstrogenic activity is exhibited by many phenolic compounds devoid of secondary alcoholic groups capable of reversible oxidation to ketone functions, and which fail (*a*) to act as coenzymes for hydrogen transfer in such systems^{1,3,4} and (*b*) to reduce pyridine nucleotides in the presence of the enzyme which catalyses the transhydrogenation Examples of such substances are 17-deoxyœstradiol^{5}, diethylstilbœstrol and hexœstrol^{6}, doisynolic and allenolic acids^{7}, and *iso*flavones such as genistein^{8} Accordingly, it became of interest to examine model enzymic systems for the transport of hydrogen by phenolic œstrogens of this nature Hochster and Quastel^{9} observed that, in the presence of manganese dioxide as a terminal hydrogen acceptor, diethylstilbœstrol acts as a hydrogen carrier in a number of dehydrogenase systems The quinone form of the œstrogen could be detected in the reaction mixture, and it was postulated to carry hydrogen in virtue of the reaction quinol $\rightleftarrows$ quinone The present experiments show that both natural and synthetic phenolic œstrogens function as hydrogen carriers in two other types of enzymic reaction The first of these is catalysed by certain phenolases and appears to involve an initial hydroxylation of the œstrogens to a corresponding *o*-diphenol, hydrogen is then transported by the change diphenol $\rightleftarrows$ quinone The second type of reaction is catalysed by some peroxidases, accelerated by traces of manganous ions, and implicates a free-radical form of the œstrogen as a hydrogen carrier It is well known that many simple, non-œstrogenic phenols can carry hydrogen in both enzyme systems However, the remarkable reactivity of many phenolic œstrogens in either type of reaction emphasizes that these substances can participate directly in hydrogen transport

Warburg^{10} demonstrated that phenolases (polyphenol oxidases) are copper proteins, and that small amounts of *o*-diphenols which are oxidized by such enzymes mediate the oxidation of reduced pyridine nucleotides^{10,11} We have found that phenolases purified from white potatoes and edible mushrooms oxidize reduced di- or tri-phosphopyridine nucleotides on the addition of trace amounts of many phenolic œstrogens The oxidations proceed to completion with the consumption of one atom of oxygen per mole of reduced pyridine nucleotide oxidized Fig 1 shows that with œstradiol-17β as carrier, a definite induction period occurs before the rate of oxidation of reduced diphosphopyridine nucleotide reaches a maximal value, whereas with the corresponding *o*-diphenol 1,3,5-œstratriene-3,4, 17β-triol^{12}, no such lag is observed Hexœstrol and 3-hydroxyhexœstrol behave in an analogous manner The activity of the mushroom and potato enzymes in these reactions parallels their phenolase activity (measured by the oxidation of tyrosine plus 3,4-dihydroxyphenylalanine) during fractionation procedures which result in purifications of more than fifty-fold The œstrogen-stimulated oxidation of reduced pyridine nucleotide is unaffected by catalase, but is abolished by heating the enzymes to 70° for 10 minutes, and by the addition of 0 001 *M* sodium cyanide The cyanide-inhibited enzyme can be reactivated by cupric ions Œstradiol-17β did not mediate the oxidation of reduced diphosphopyridine nucleotide in the presence of hæmocyanin, of copper sulphate (0 0001 *M*) or of the soluble phenolase of spinach leaves

A free phenolic hydroxyl group is essential for both natural and synthetic œstrogens to transport hydrogen by these phenolase-catalysed reactions Thus, nearly equivalent carrier activity is found with œstradiol-17α or -17β, 17-deoxyœstradiol, œstrone and œstriol, while 3-deoxyœstradiol-17α or -173 are completely inert *bis*-Dehydrodoisynolic acid is a good hydrogen carrier, whereas the corresponding O-methyl ether is inactive At least one phenolic hydroxyl group must be present in analogues of diethylstilbœstrol and hexœstrol^{13} to exert this carrier function The activity of natural and synthetic œstrogens is affected markedly by minor structural changes in the molecule Thus, 1-methyl-œstradiol-17β, 2-nitro-œstrone and 4-nitro-œstrone will not act as hydrogen carriers, and are without influence upon the action of œstradiol-17β 6β-Hydroxyœstradiol-17β (which does not mediate the oxidation of reduced diphosphopyridine nucleotide) and 7-keto-œstrone (which has approximately 10 per cent of the activity of œstradiol-17β), both at equimolar concentrations, depress the hydrogen-transporting activity of œstradiol-17β The concentrations of œstrogens permitting 50 per cent of the maximal rate of oxidation of reduced diphosphopyridine nucleotide by potato phenolase were found to be 1×10^{-6} *M* for 1,3,5-œstratriene-3,4, 17β-triol, 3×10^{-6} *M* for œstradiol-17β, œstrone, 17-deoxyœstradiol and hexœstrol, and 1×10^{-5} *M* for genistein

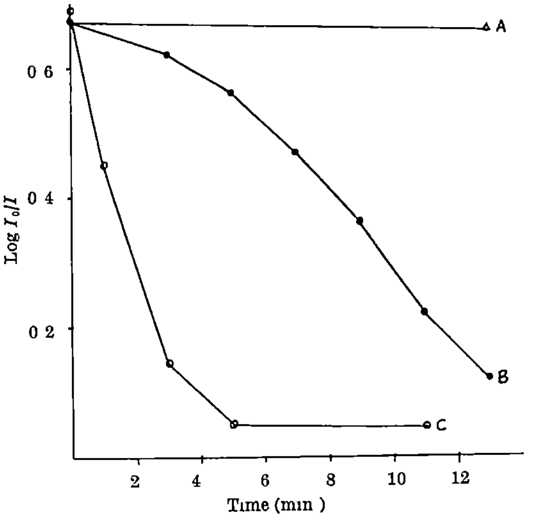

Fig 1 Oxidation of reduced diphosphopyridine nucleotide by phenolase in the presence of potato phenolase Sodium phosphate buffer *p*H 7 4 (0 05 *M*), 15 μgm œstrogenic phenol in 0 01 ml dioxane, 200 μgm potato phenolase, 0 3 μmoles DPNH Total vol 3 c c Light path 1 cm Wave-length 340 mμ 25° C in air *A*, no œstrogen, *B*, œstradiol 17β, *C*, 1, 3, 5, œstratriene- 3, 4, 17β triol

Hydrogen transport by phenolic œstrogens under these conditions can be described as follows The induction period with monophenolic œstrogens probably reflects the time required for the phenolase to catalyse hydroxylation to *o*-diphenol derivatives The diphenol is oxidized by the phenolase to the corresponding quinone, and the quinone is then reduced by the reduced pyridine nucleotide Although it is not known whether the latter reaction is enzymically catalysed or not, it may be mentioned that pyridine nucleotide-menadione^{14} and -quinone^{15} reductase activity is readily separable from the œstrogen-mediated reactions during purification of the phenolases In accordance with this formulation it was found that, after aerobic incubation with potato phenolase, diphosphopyridine nucleotide, ethanol and crystalline yeast alcohol dehydrogenase,

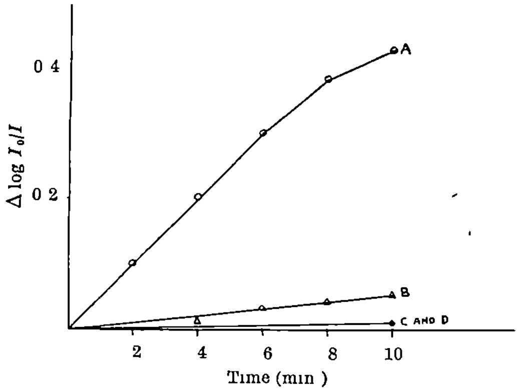

Fig 2 Oxidation of reduced diphosphopyridine nucleotide by peroxidase in the presence of œstrogenic phenols *Tris* (hydroxymethyl) amino methane buffer (0 03 *M*) *p*H 7 4, 0 3 μmole DPNH, 20 μgm œstradiol-17β in 0 02 ml ethanol, 0 03 μmole $MnCl_2$, 5 μgm horseradish peroxidase Total vol 3 c c Light path 1 cm 25° C in air Wave-length 340 mμ *A*, complete system, *B*, omit œstradiol-17β, *C* and *D*, omit $MnCl_2$ or œstradiol-17β and $MnCl_2$

œstradiol-17β is converted to at least two other substances which migrate much more slowly than œstradiol-17β when chromatographed on paper with a heptane–methanol solvent[16]

These findings are undoubtedly related to the reported inactivation of œstrogens by plant phenolases[17] It is possible that they have some bearing on the formation of hydroxylated derivatives of œstradiol-17β catalysed by liver microsomes in the presence of reduced triphosphopyridine nucleotide and oxygen[18], the stimulation of formate incorporation into isolated uterus by the addition of *o*-hydroxylated derivatives of œstradiol-17β *in vitro*[12], and the urinary excretion of 2-methoxy forms of œstrone[19] and œstriol[20]

An entirely different type of hydrogen transport mediated by phenolic œstrogens is catalysed by peroxidases purified from either horse radish or cow's milk Fig 2 shows that reduced diphosphopyridine nucleotide is oxidized upon the addition of peroxidase and low concentrations of œstradiol-17β, and that the reaction is stimulated by 10^{-5} *M* manganous chloride Manometric experiments revealed that the oxidation of reduced diphosphopyridine nucleotide proceeds to completion with the consumption of one atom of oxygen per mole of reduced diphosphopyridine nucleotide oxidized Reduced triphosphopyridine nucleotide and reduced nicotinamide mononucleotide are oxidized at the same rate as reduced diphosphopyridine nucleotide This phenol-dependent oxidation of reduced pyridine nucleotide does not require the addition of hydrogen peroxide Under these experimental conditions, hydrogen peroxide does not induce the oxidation of reduced diphosphopyridine nucleotide unless an appropriate phenol is present With œstradiol-17β, or hexœstrol or diethylstilbœstrol as co-factors, the oxidation of reduced diphosphopyridine nucleotide is abolished by 0 001 *M* sodium cyanide and by catalase 50 per cent of the maximal rate of oxidation was found with a final concentration of œstradiol-17β of 8×10^{-6} *M* A free phenolic hydroxyl group is required for œstrogens to exert a carrier function In contrast to the phenolase-catalysed reactions described above, no induction period is observed when monophenolic œstrogens mediate the oxidation of reduced diphosphopyridine nucleotide in the peroxidase system Moreover, many *o*-diphenols which act as hydrogen carriers in the phenolase-dependent reactions are incapable of transporting hydrogen in the peroxidase system and inhibit the action of œstradiol-17β therein, for example, adrenalin, noradrenalin, and 3-hydroxytyramine The behaviour of phenolic œstrogens under these conditions is similar to that described for a number of simple phenols by Akazawa and Conn[21] The latter authors have pointed out the similarity between such phenol-dependent reactions and the oxidation of dihydroxyfumaric acid catalysed by peroxidase[22] They suggested that a ternary complex of peroxidase, Mn^{++} and hydrogen peroxide catalyses the oxidation of the phenol (*R*OH) by oxygen to an oxidized form (*R*O , presumably of a free-radical nature) and hydrogen peroxide The latter substance could then, by the action of peroxidase, oxidize another molecule of the phenol to the oxidized (free-radical) form Reduced diphosphopyridine nucleotide could further reduce the oxidized phenol The process can be envisaged as

$$\begin{array}{c} 2R\mathrm{OH} + \mathrm{O_2} \rightarrow 2R\mathrm{O} + \mathrm{H_2O_2} \\ 2R\mathrm{OH} + \mathrm{H_2O_2} \rightarrow 2R\mathrm{O} + 2\mathrm{H_2O} \\ \underline{4R\mathrm{O} + 2\mathrm{DPNH} + 2\mathrm{H^+} \rightarrow 4R\mathrm{OH} + 2\mathrm{DPN^+}} \\ 2\mathrm{DPNH} + 2\mathrm{H^+} + \mathrm{O_2} \rightarrow 2\mathrm{DPN^+} + 2\mathrm{H_2O} \end{array}$$

Our ability to recover œstradiol-17β unchanged from this peroxidase system is in agreement with this formulation

These experiments suggest strongly that phenolic œstrogens can transport hydrogen in virtue of the reaction phenol ⇄ phenoxy radical Electron spin resonance studies by Rexroad and Gordy[23] have shown that hexœstrol can be converted to a free-radical form(s) by irradiation It is of interest that the injection of physiological doses of both natural and synthetic œstrogens into ovariectomized rats induces enormous increases in the activity of uterine peroxidase[24]

It is a pleasure to acknowledge many valuable discussions with Drs Charles Huggins, Paul Talalay, Gerhard Closs, and the generous gifts of compounds from Drs G C Mueller and E V Jensen This work was supported by grants from the American Cancer Society, Inc

[1] Talalay, P , and Williams-Ashman, H G , *Proc U S Nat Acad Sci* , **44**, 15 (1958)
[2] Talalay, P , Hurlock, B., and Williams-Ashman, H G , *Proc U S Nat Acad Sci* , **44**, 862 (1958)
[3] Villee, C A , and Hagerman, D D , *J Biol Chem* , **233**, 42 (1958)
[4] Villee, C A , *Cancer Res* , **17**, 507 (1957)
[5] Huggins, C , and Jensen, E V , *J Exp Med* , **100**, 241 (1954)
[6] Dodds, E C , Goldberg, L , Lawson, W , and Robinson, R , *Nature*, **141**, 247 (1938)
[7] Miescher, K , *Chem Rev* , **43**, 367 (1948)
[8] Bradbury, R B , and White, R E , *J Chem Soc* , 3447 (1951)
[9] Hochster, R M , and Quastel, J H , *Nature*, **164**, 865 (1949)
[10] Kubowitz, F , *Biochem Z* , **292**, 221 (1937)
[11] Kubowitz, F , *Biochem Z* , **293**, 308 (1937)
[12] Mueller, G C , *Nature*, **176**, 127 (1955)
[13] Pratt, R J , and Jensen, E V , *J Amer Chem Soc* , **78**, 4330 (1956)
[14] Wosilait, W D , and Nason, A , *J Biol Chem* , **206**, 255 (1954)
[15] Wosilait, W D , and Nason, A , *J Biol Chem* , **208**, 785 (1954)
[16] Dao, T L Y , *Endocrinology*, **61**, 242 (1957)
[17] Graubard, M , and Pincus, G , *Proc U S Nat Acad Sci* , **27**, 149 (1941)
[18] Mueller, G C , and Rumney, G , *J Amer Chem Soc* , **79**, 1004 (1957)
[19] Krachy, S , and Gallagher, T F , *J Biol Chem* , **229**, 519 (1957)
[20] Fishman, J , and Gallagher, T F , *Arch Biochem Biophys* , **77**, 511 (1958)
[21] Akazawa, T , and Conn, E E , *J Biol Chem* , **232**, 403 (1958)
[22] Chance, B , *J Biol Chem* , **197**, 577 (1952)
[23] Rexroad, H N , and Gordy, W , *Proc U S Nat Acad Sci* , **45**, 256 (1959)
[24] Lucas, F V , Neufeld, H A , Utterback, J G , Martin, A P , and Stotz, E , *J Biol Chem* , **214**, 775 (1955)

ACTIVATION AND INHIBITION OF THE ARYLESTERASE OF HUMAN SERUM

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HUMAN blood plasma contains at least two different enzymes capable of hydrolysing phenylacetate[1,2]. One of them is a cholinesterase, the other an aromatic esterase (arylesterase)[3]. The present studies deal with arylesterase and stem from our observation that the disodium ethylenediaminetetraacetate ('Sequestrene') added to prevent coagulation in blood samples inhibited arylesterase without affecting cholinesterase activity. Since human arylesterase has been reported to be remarkably resistant to many of the usual inhibitors[2], we have supposed that further studies of the inhibition and acceleration of activity of arylesterase by selected agents would prove of interest. In particular, tests of the effects of metal ions and sequestering agents were indicated.

The activity of the enzyme was assayed with a modification of Zeller's[4] method in a Cary recording spectrophotometer at a wave-length of 2800 A. The instrument was equipped with an expanded scale (0–0.1) slide wire assembly, which greatly increased the extent of registration. The concentration of phenylacetate was 1×10^{-3} M. In the early runs of the investigation, the source of enzyme was pooled, heparinized human plasma. Later, pooled, normal human serum gave similar results. The serum was diluted 1 : 2,000 v/v; the absorption cells of the spectrophotometer contained 0.002 ml. of serum in a *tris*-hydroxymethyl aminomethane (*tris*) buffer of *p*H 7.4. At this dilution the contribution of cholinesterase to the hydrolysis of phenylacetate was found to be negligible in the sera of healthy donors. In the experiments where the effects of inhibitors or activators were tested on the cholinesterase, the source of enzyme was purified human plasma cholinesterase preparation ('Cholase', Cutter Laboratories). This preparation was void of arylesterase activity. The temperature was kept constant at 27° C. In a few control studies, the usual Warburg manometric technique or an automatic recording titrator (Titrigraph, Radiometer) gave similar results. The effect of most of the compounds on the enzyme was tested after 5-min. pre-incubation. All concentrations given in this report show the final dilution of the substance used.

It was found that the hydrolysis of phenylacetate by arylesterase increased in the presence of calcium chloride[5]. The sensitivity of the different serum samples toward calcium varied to a great extent. On the average, an 85 per cent acceleration was observed at 1×10^{-4} M concentration of calcium chloride. Ethylenediaminetetraacetate also enhances the activity of arylesterase in the lower concentration ranges. This activation changes sharply to inhibition at concentrations higher than 10^{-5} M. The enzyme was totally inhibited by 2.5×10^{-5} M ethylenediaminetetraacetate. When the sodium salt of the calcium–ethylenediaminetetraacetate complex ('Sequestrene Na_2Ca', calcium-ethylenediaminetetraacetate) was used instead of ethylenediaminetetraacetate, no inhibition was observed. On the other hand, the magnesium – ethylenediaminetetraacetate complex inhibited similarly to ethylenediaminetetraacetate. This latter effect was probably due to the fact that calcium from the system replaced magnesium in the complex. The stability constant of ethylenediaminetetraacetate with Ca^{2+} is log K = 10.59 and that of Mg^{2+}, 8.69. Another ethylenediaminetetraacetate derivative, ethylenediamine di(*o*-hydroxyphenyl acetic acid) ('Chel *DP*'), which has little tendency to co-ordinate with calcium (log K for Ca^{2+} is 1.6), did not inhibit arylesterase. In some preliminary studies, swine serum arylesterase[6] was also inhibited by ethylenediaminetetraacetate.

The results obtained with calcium prompted us to investigate the effect of other cations on the enzyme. Arylesterase was inhibited by a number of rare earth, alkaline earth and metal ions. The best inhibitor was $GdCl_{50}$ $I_{50} = 4 \times 10^{-8}$ M; the weakest, $MgCl_2$, $I_{50} = 4 \times 10^{-4}$ M. The inhibitory effect decreased in the following order: $GdCl_3$, $CeCl_3$, $LaCl_3$, $Y(NO_3)_3$, $SmCl_3$, $CdSO_4$, $HgCl_2$, $AgNO_3$, $PbCl_2$, $ZnSO_4$, $NiSO_4$, $CoSO_4$, $CuCl_2$, $MnSO_4$, $BaCl_2$, $SrCl_2$, $MgCl_2$.

Under the experimental conditions used, the most interesting feature of these series was the inhibition by low concentrations of the stable trivalent rare earth cations and by somewhat higher concentrations of heavy metals. Yttrium and the rare earth ions were about equally active, the I_{50} values falling in the 10^{-7} to 10^{-8} M range. *p*-chloromercuryphenyl sulphonic acid also inhibited the enzyme ($I_{50} = 3 \times 10^{-6}$ M). Thus, in addition to rabbit[3], the human enzyme is also sensitive to sulphydryl agents. Sodium citrate and an amino-oxidase inhibitor, 1-phenyl-2-hydrazinopropane (*JB*516), inhibited the enzyme in a relatively high concentration. The I_{50} values were 6×10^{-4} M and 2×10^{-4} M, respectively.

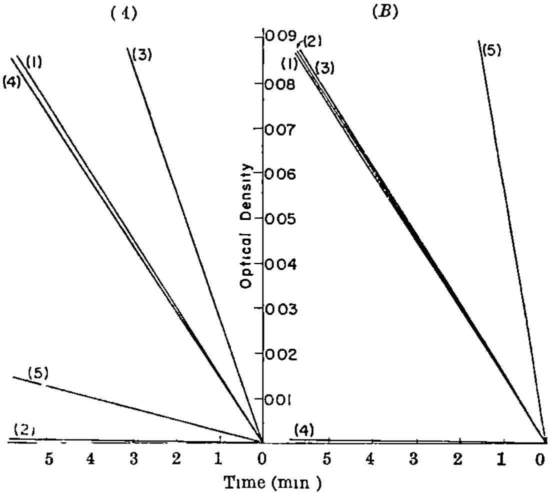

Fig. 1. Inhibition and acceleration of the hydrolysis of phenylacetate by human serum arylesterase (*A*) and by purified, concentrated human plasma cholinesterase (*B*). (1) control; (2) ethylenediaminetetraacetate 2.5×10^{-5} M; (3) calcium chloride, 1×10^{-4} M; (4) eserine, 2.5×10^{-6} M; (5) *JB*516, 1×10^{-3} M

As indicated above, 2 5 × 10^{-5} *M* ethylenediaminetetraacetate inhibited the enzyme completely Presumably this inhibition is due to removing the calcium from the enzyme molecule The acceleration by low concentrations of ethylenediaminetetraacetate may reflect a binding of an inhibitor present in the system When a 10^{-4} *M* calcium chloride solution was added soon after 5 × 10^{-5} *M* ethylenediaminetetraacetate to the enzyme, the inhibition gradually decreased and up to 70 per cent of the normal activity was restored If, instead of calcium, magnesium was added, only a negligible decrease in inhibition was observed

When a 1 10 v/v dilution of serum was dialysed against a *tris*-buffer at 4° C , the activity of arylesterase decreased 65 per cent within 17 hr , but it could be partially restored by adding calcium to the dialysed enzyme If the enzyme solution contained ethylenediaminetetraacetate in the dialysis tube, 95 per cent of the activity disappeared during the dialysis and calcium did not reactivate the enzyme This indicates that the removal of calcium from the arylesterase led to irreversible changes When the enzyme solution contained calcium-ethylenediaminetetraacetate during the dialysis instead of ethylenediaminetetraacetate, the enzyme activity remained the same as that of the dialysed control Finally, when the enzyme was dialysed against a *tris*-buffer which contained 10^{-4} *M* calcium chloride, the activity did not diminish during dialysis

Others have shown earlier that phenylacetate is hydrolysed by both arylesterase and the cholinesterase of human serum or plasma However, Fig 1 summarizes some of the differences between the two enzymes In this figure the increase in optical density is plotted against time in minutes This increase is due to the amount of phenol liberated which in turn is a function of the enzymic activity Part *A* shows that arylesterase was inhibited by ethylenediaminetetraacetate and *JB*516, activated by calcium, and unaffected by eserine[1-3] Cholase (part *B*), as expected, was inhibited by eserine The activity of cholinesterase with phenylacetate substrate was accelerated by *JB*516 and unaffected by 1 × 10^{-4} *M* Ca^{2+} and ethylenediaminetetraacetate

The results summarized in this report indicate the dependence on calcium of the arylesterase as well as the sensitivity of this enzyme toward several inhibitors A detailed account of the work with arylesterase and on the effect of *JB*516 on cholinesterase will be published elsewhere

Ethylenediaminetetraacetate, its derivatives, and the technical data were kindly supplied by Geigy Industrial Chemicals , *JB*516 by Lakeside Laboratories

[1] Mounter, L A , and Whittaker, V P , *Biochem J* , **54**, 551 (1953)

[2] Augustinsson, K B , *Nature*, **181**, 1786 (1958)

[3] Aldridge, W N , *Biochem J* , 53, 110 (1953) , **53**, 117 (1953) , **54**, 442 (1953)

[4] Zeller, E A , *Arch Biochem Biophys* , **61**, 231 (1956)

[5] Bernsohn, J , Zeller, E A , and Cochrane, L S G , *Fed Proc* , **13**, 183 (1954)

[6] Augustinsson, K B , and Olsson, B , *Biochem J* , **71**, 477 (1959) , **71**, 484 (1959)

REDUCTION OF TOXICITY OF CATIONIC MACROMOLECULES BY COMPLEXING WITH ANIONIC DERIVATIVES OF SYNTHETIC POLYGLUCOSES

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ANIONIC derivatives of synthetic polyglucoses were found[1,2] to inhibit enzyme activity of cationic proteins in consequence of the formation *in vitro* of complexes through electrostatic forces In the case of lysozyme, small amounts of salt prevented complex formation , when added after complexing, salt caused dissociation accompanied by reversal of the inhibition On the other hand, low salt concentration did not prevent complexing with ribonuclease, hyaluronidase and some other enzymes

The present communication reports experiments designed to ascertain whether the toxicity of cationic drugs of high molecular weight can be effectively blocked by analogous complexing with anionic polyglucose derivatives in the living animal, where complex formation can be affected by the salt and by the competing cationic macromolecules which are present It was found that the toxicity of a number of such materials could, indeed, be reduced Our findings extend the recent report of Higginbotham[3] that heparin, a naturally occurring anionic polysaccharide, reduced the toxicity of polymyxin-*B* in mice

In the current experiments the compounds were employed in solution in pyrogen-free water , the total volume of fluid administered was kept between 0 1 and 0 4 ml per animal Ten-week old strain *C* mice of both sexes, weighing 18–20 gm , were employed in groups of ten The mice were observed for several hours after treatment, and 24-hr survival was tabulated

The cationic substances administered at toxic level were polymyxin-*B*, protamine, streptomycin, and neomycin Toxic effects were found to be reduced by subsequent administration of the sodium salts and of the free acid forms of the sulphate and carboxyl derivatives of polyglucose Two sulphated preparations were employed, both derived from a polyglucose with a number average molecular weight of about 20,000 , the number of sulphate groups per anhydro-glucose unit was 3 and 0 6, respectively The former was preparation *H*[4] $[\eta]$ = 0 04 , the latter was preparation *D*[4], $[\eta]$ = 0 04 , the free acid form was obtained by treatment with a cation exchange resin The carboxyl derivative contained 17 per cent carboxyl (preparation *e*)[5]

Polymyxin-*B* was given in a standard dose of 0 5 mgm /mouse The mice reacted as follows within 3 min they were prostrated , respiratory embarrassment and severe convulsions developed in about 10 min , they began to die in about 20 min , those few that survived for 40 min recovered and were still alive at 24 hr

Table 1 COUNTERACTION OF TOXICITY OF CATIONIC MACROMOLECULES BY SUBSEQUENT ADMINISTRATION (5 MIN LATER) OF ANIONIC POLYGLUCOSE DERIVATIVES

Toxicity from		Counter treatment		24-hr survival (10 mice per group)
Cationic substance	Mgm / mouse	Polyglucose derivative	Mgm / mouse	
Polymyxin-*B*	0 5	—	—	2
		Sulphate *H* (acid form)	1	10
		Sulphate *H*	0 5	10
		Sulphate *H*	1	9*
		Sulphate *H*	1	8†
		Sulphate *H* (Na salt)	1	10
		Carboxyl (acid)	1	10
		(acid)	0 5	10
		(Na salt)	0 5	10
Protamine	3	Control	—	0
		Sulphate *H* (acid)	3	10
Streptomycin	8	Control	—	2
		Sulphate *H* (acid)	8	8
Neomycin	3	Control	—	4
		Sulphate *H* (acid)	6	8
			10	6

* 10 min interval between injections
† 20 min interval between injections , two mice were already dead

When polyglucose sulphate was administered 5 min after this dose of polymyxin-*B*, all the mice recovered rapidly and behaved normally within 30 min , even when the counteracting dose was delayed for 10 or 20 min . at which time some of the mice were already dead, the moribund animals recovered Similar counteraction of the toxicity of polymyxin was obtained with both the salt and the acid forms of the sulphate and carboxyl derivatives (Table 1) Analogous protection was obtained against the lethal effect of protamine However, the toxicity of streptomycin and of neomycin was only partially reduced even when larger amounts of polyglucose sulphate were used This is in line with the requirement for high molecular weight in the blocking[2] of enzyme activity

In the second set of experiments (Table 2) the polyglucose derivative was injected first, subcutaneously at the nape, while the cationic substance was given intraperitoneally In the experiments with polyglucose sulphate and polymyxin-*B*, protection against lethality and toxic manifestations was virtually complete when the interval between the injections was 2–90 min The protective effect of the carboxyl derivative was of shorter duration Polyglucose sulphate (1 mgm) yielded partial protection against the lethal dose of protamine (3 mgm)

Table 2 PROTECTION FROM LETHAL TOXICITY OF POLYMYXIN-*B* (0 5 MGM /MOUSE) BY PRIOR INJECTION OF ANIONIC POLYGLUCOSE DERIVATIVES AT A DIFFERENT SITE

Protective treatment		Time between injections	24-hr survival (10 mice per group)
Polyglucose derivative (acid forms)	Mgm / mouse		
None	—	—	2
Sulphate *H*	1	1 day	4
,,	1	300 min	3
,,	1	180 ,,	8
,,	1	90 ,,	10
,,	1	60 ,,	10
,,	1	30 ,,	10
,,	1	5 ,,	10
,,	1	2 ,,	9
,,	0 5	30 ,,	6
,,	0 25	30 ,,	5
Carboxyl	1	5 ,,	10
,,	1	10 ,,	1
,,	2	10 ,,	8

These experiments showed that polyglucose sulphate afforded protection promptly even when injected by a different route and at a site distant from that employed for the polymyxin. In addition to the direct action of the anionic derivative upon the cationic drug, it is possible that mobilized acid polysaccharide of tissue origin also may contribute to the blocking of the lethal effect[6]

Synthetic polyglucose derivatives can provide molecular model systems suitable for the study of macromolecular interactions and of the consequent biological changes Polyglucoses can be prepared different in molecular weight and in degree of branching[7] They have a highly branched, spherical structure[8], and possess numerous alcoholic hydroxyl groups suitable for graded substitution with dissociating groups For example, polyglucose sulphates with different degrees of sulphation[4] can be used to study the effect of molecular parameters (size, charge density, etc) on macromolecular interaction[1,2]

The effect of difference in charge density of polyglucose sulphates upon their potency in counteracting the lethal effect of polymyxin-*B* was also investigated Preparations *H* and *D* of polyglucose sulphate sodium salt, described above, were given as in the experiments summarized in Table 1, that is, the anionic derivative was injected 5 min after the lethal dose of polymyxin-*B* (both given intraperitoneally) Table 3 shows that the polyglucose sulphate with the higher charge density gave greater protection , for example, at the 0 1-mgm level, preparation *H* gave complete protection while preparation *D* gave none

Table 3 EFFECT OF CHARGE DENSITY OF POLYGLUCOSE SULPHATE ON COUNTERACTION OF TOXICITY OF POLYMYXIN-*B* (0 5 MGM /MOUSE INJECTED 5 MIN EARLIER)

Polyglucose sulphate sodium salt			24-hr survival (10 mice per group)
Preparation	SO_4/anhydro-glucose unit	Mgm /mouse	
—	—	—	1
H	3	0 5	10
D	0 6	0 5	9
H	3	0 25	10
D	0 6	0 25	3
H	3	0 1	10
D	0 6	0 1	1
H	3	0 05	4

Thus it has been found that such anionic derivatives of polyglucose were capable of protecting mice against a lethal dose of cationic macromolecules not only when administered first, but also by counteracting toxicity in moribund animals Furthermore, the greater their charge density the greater was their effectiveness

Cationic polyglucose derivatives have now been synthesized Their interaction with naturally occurring anionic macromolecules, and the effect of such interaction on the biological properties of the latter, are projected

[1] Mora, P T , and Young, B G , *Nature*, **181**, 1402 (1958)
[2] Mora, P T , and Young, B G , *Arch Biochem Biophys* (in the press)
[3] Higginbotham, R D , and Carter, P B , *Antibiotics and Chemotherapy*, **7**, 527 (1957)
[4] Wood, J W , and Mora, P T , *J Amer Chem Soc* , **80**, 3700 (1958)
[5] Mora, P T , Merler, E , and Maury, P , *J Amer Chem Soc* (in the press)
[6] Cf Higginbotham, R D , *Ann N Y Acad Sci* , **73**, 186 (1958)
[7] Mora, P T , Wood, J W , Maury, P , and Young, B G , *J Amer Chem Soc* , **80**, 693 (1958)
[8] Mora, P T , *J Polym Sci* , **23**, 345 (1957)

QUANTITATIVE ASSAY OF COMPOUNDS IN ISOLATED, FRESH NERVE CELLS AND GLIAL CELLS FROM CONTROL AND STIMULATED ANIMALS

By PROF. HOLGER HYDÉN

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FOR cytophysiological studies it is desirable to express results in amounts of biologically important substances per cell. The same trend seems now to exist in neurocytology for unicell analyses as is the case in electrophysiology. This article gives an account and applications of the methods used in our laboratory for the determination of substances expressed as $\mu\mu$gm. per fresh nerve cell or per volume of fresh glial cells.

Lowry[1] and his associates[2] have dissected nerve cells from thick, frozen and dried sections and have obtained excellent results. We prefer to dissect nerve cells from a cut surface through the desired locus of the fresh tissue, immersed in isotonic sucrose solution. The dissection is made free-hand under a stereomicroscope, at a magnification of 64 or 100. A stainless thread, 15 or 18μ in diameter, and sharpened to $\sim 2\mu$ (manufactured by Kanthal AB, Hallstahammar, Sweden), is used for lifting out the nerve cells into an isotonic sucrose solution. The main part of the dendrites comes with the cell (Fig. 1). Usually a very small amount of methylene blue in sucrose solution is applied to the cut surface for some seconds. The stain is taken up by the synapses, which are seen as a finely dotted border around the area occupied by the unstained nerve cell. The cell is removed before it takes up the dye, and transferred to the substrate or to the sucrose solution, where it is freed from adhering glia by gentle manipulation. Note the density of synapses on the surface of the soma and dendrites of the fresh nerve cell (Fig. 1). Nerve cells sampled in this way are used for the determination of the weight,

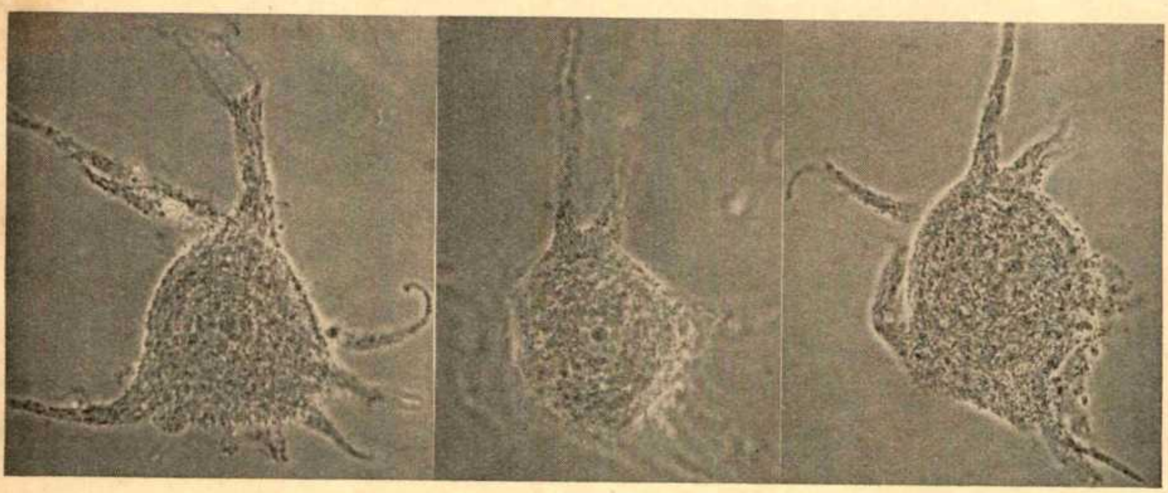

Fig. 1. Fresh nerve cells dissected out free-hand, photographed in the phase-contrast microscope. Slightly stained with methylene blue to show density of the synapses as small knobs on the surface. (× c. 200)

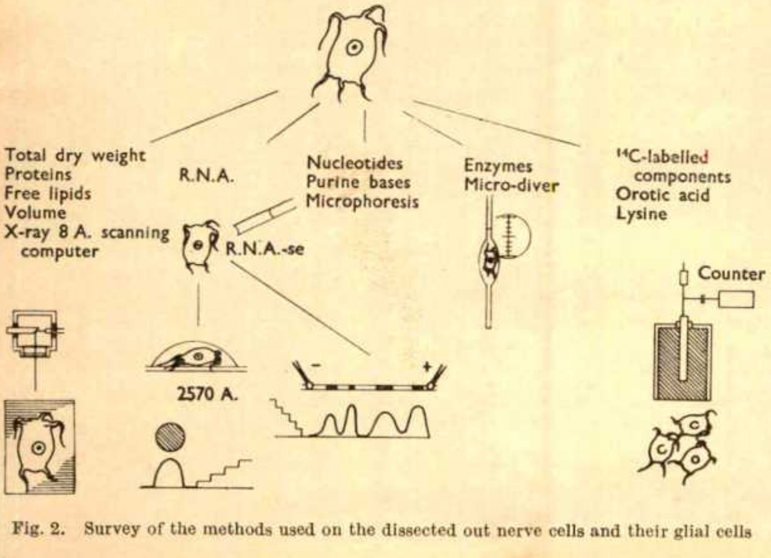

Fig. 2. Survey of the methods used on the dissected out nerve cells and their glial cells

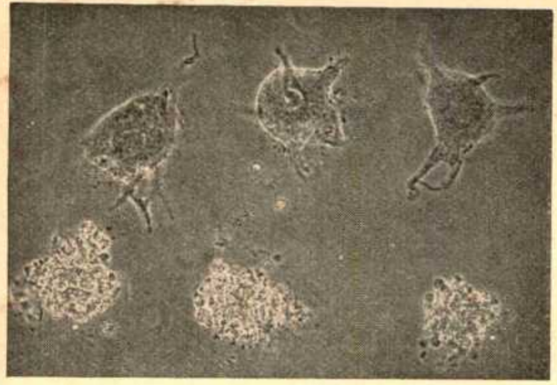

Fig. 3. Fresh nerve cells plus the neuroglial cells originally closely surrounding each cell dissected free and trimmed to the same volume as that of their nerve cell and placed in a row below the nerve cells. The collection of glial cells slightly pressed against the glass. (Phase contrast, × *c*. 30)

a protein and a free lipid fraction[3,4], ribonucleic acid[5], nucleotides[6,7], of labelled substances such as ^{14}C-orotic acid and ^{14}C-lysine[8], and of enzyme activities[9] (Fig. 2). The oligodendrocytes closely surrounding the nerve cell easily come off in the substrate and adhere to each other, and the collection may assume a spherical form. It can easily be trimmed to approximately the same volume as that of the nerve cell to which they belong (Fig. 3). The collection of glial cells is freed from larger parts of axons or dendrites.

No method hitherto described is ideal for volume determination of such an irregular cell as the nerve cell ; not even the interference microscope technique. The following method seems adequate. The total dry weight of a fresh nerve cell including the main part of the dendrites, precipitated with 1 N cold perchloric acid for 30 sec. and washed and dried, is determined by X-ray microradiography at 8–10 A. The X-radiogram is evaluated by our scanning cell analyser, which gives the weight of the cell based on up to 12,000 measurements in 4 min. The dry weight per unit volume of the nerve cell is determined on a frozen and dried section prepared in the cryostat. The volume of the fresh cell irrespective of its irregular form is the total weight divided by the mass per μ^3 of the cell material. The value for the organic material in the nucleus has been found to be as high as that in the cytoplasm.

It was found that the mass per unit volume of fresh glial cells is 0·20 $\mu\mu$gm./μ^3, which is the same as that of their nerve cells. Hence, it is possible to compare nerve cells and glial cells on the same volume basis.

Rabbits were subjected to mild rotation, through 120° horizontally and 30° vertically, 35 turns/min., for 25 min./day for 6 days. The results—those on the effect of stimulation on the nerve cells—will be published in detail elsewhere, in collaboration with Dr. A. Pigon.

Table 1. DATA FROM 80 DEITER'S NERVE CELLS, RABBIT
Values in $\mu\mu$gm. Vol. averaged 93·200 μ^3. The dry weight as $\mu\mu$gm./μ^3 was 0·23

Structure	Dry weight	Proteins	Lipids soluble in chloroform	Ribonucleic acid	Ribonucleic acid in per cent of dry proteins
Soma	20,800	16,600	4,200	1,100–1,300	7
Nucleoplasm	800	650	200	~20	
Nucleolus	100				
Nerve cell total	21,700	17,250	4,400		

The ribonucleic acid content of the oligodendrocytes expressed per volume, equivalent to that of the nerve cell, was in 15 analyses found to be approximately 100 $\mu\mu$gm., that is, ten times less than the ribonucleic acid content of the nerve cell. This is noteworthy since the number of glial cells surpasses that of the neurons by a factor of probably more than ten. Thus, it is not possible to state that ribonucleic acid found in bulk analyses of the central nervous system is that of the nerve cells, as is stated in several papers.

Table 2. EFFECT OF VESTIBULAR STIMULATION ON THE DRY WEIGHT OF DEITER'S CELLS, RABBIT
Values in $\mu\mu$gm.

Nerve cells	No.	Weight	V† (per cent)	P
Controls	50		19	0·01**
Stimulated 25 min./day for 6 days	47	24,300	31	

† V, variation coefficient.

The effect of the vestibular stimulation on these cells, second in the neuronal chain, is thus a significant increase of the dry weight of organic material. The conclusion is that the increased functional demands cause a production of intraneuronal organic material, the proteins included. This fits with earlier findings using another type of technique[10].

With measurements also on nerve cell plus same volume of glial cells altogether 500 cells have been measured.

In the controls, the respiratory enzyme activity is twice as high in the glial cells as in the nerve cell they belong to, measured on the same volume. This fits well with the results of the same enzyme activity in spinal ganglion cells and in their satellite cells[9],

Table 3. EFFECT OF VESTIBULAR STIMULATION ON THE RESPIRATORY ENZYME ACTIVITY IN DEITER'S CELLS AND IN THE SAME VOLUME OF THEIR GLIAL CELLS
Enzyme activity as 10^{-4} μl. O_2/hr./cell at 37°. Cells measured one, two or three at a time in one micro-diver

	Cytochrome oxidase				Succinoxidase			
	No. of cells	Mean	P	Ratio	No. of cells	Mean	P	Ratio
Nerve cells, stimulated	25	7·6	0·01**	1·8	57	6·0	0·001***	2·8
Nerve cells, controls	34	4·2			35	2·1		
Glial cells, stimulated	36	3·0	0·001***	0·3	41	4·0	0·6	0·9
Glial cells, controls	34	11·5			33	4·5		

and also with respect to other enzyme activities in this type of nerve cells[11]

The vestibular stimulation for 25 min /day for 6 days increased the respiratory enzyme activity of the nerve cells, belonging to the second neuron of this pathway, to a higher level Considering that the organic mass per nerve cell also increased, it may be assumed that the stimulation caused an increase in the enzyme concentration as well as activity But, at the same time, the enzyme activity in the glial cell decreased, and significantly so in the case of cytochrome oxidase It is impossible at present to interpret these results The following tentative working hypothesis may be presented Several observations support the view that the glial cells, especially the oligodendrocytes, are donors of energy or of food to the nerve cell they serve It is also known that there occurs a shift in the substrate for the metabolism of the stimulated central nervous system compared with the non-stimulated The central nervous system can furthermore burn substances other than glucose[12]

Therefore, when the nerve cells demand more energy at the increased activity, they are presumably given priority to the necessary substances by the neuroglia These cells may cut down their metabolism, which is reflected in the decreased cytochrome oxidase activity There may be an inhibiting mechanism at that terminal step, at increased neuronal activity, and the glial cells may be the cellular parts of the central nervous system which have to resort to substances other than glucose

These studies have been supported by the Rockefeller Foundation and by the Swedish Medical Research Council

[1] Lowry, O H , *J Histochem Cytochem* , **1**, 420 (1953)

[2] Robins, E , *Exp Cell Res* , Supp 4, 241 (1957)

[3] Brattgård, S O , and Hydén, H , *Int Rev Cytol* , **3**, 455 (1954)

[4] Hydén, H , Proc IV Int Cong of Biochemistry, Symp III, 1 (1958)

[5] Edström, J -E , *J Neurochem* , **3**, 100 (1958)

[6] Edström, J -E , and Hydén, H , *Nature*, **174**, 128 (1954)

[7] Edström, J -E , *Microchem J* , **2**, 71 (1958)

[8] Brattgård, S O , Hydén, H , and Sjostrand, J , *Nature*, **182**, 801 (1958)

[9] Hydén, H , Løvtrup, S , and Pigon, A , *J Neurochem* , **2**, 304 (1958)

[10] Hamberger, C -A , and Hydén, H , *Acta Oto-Laryngol* , Supp 75, 53, 82 (1949)

[11] Lowry, O H , in "Progress in Neurobiology II Ultrastructure and Cellular Chemistry of Neural Tissue", ed H Waelsch, 69 (Hoeber-Harper, New York, 1957)

[12] Geiger, A , "Metabolism of the Nervous System", ed D Richter, 245 (Pergamon Press, London, 1957)

VIRAL MULTIPLICATION AND CELLULAR HYPERPLASIA

By Prof COUNCILMAN MORGAN

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IN assessing the mechanisms whereby certain viruses cause either cellular proliferation or neoplasia, it is obviously important to determine whether replication of the virus augments or inhibits mitosis of the host cell Data bearing directly on this problem are scant Dawson[1], studying the histology of focal lesions in chicken chorioallantoic membranes infected with herpes simplex virus, reported necrosis and hyperplasia of the ectodermal cells but found that only "some of the cells show the characteristic intranuclear changes of infection" Burnet *et al* [2] confirmed these observations and noted that the proliferation followed initial necrosis of the ectoderm In addition, these authors described hyperplasia of the entodermal cells without the nuclear swelling, margination of chromatin and formation of inclusion bodies which were believed to accompany viral infection Later, Beveridge and Burnet[3] found inclusion bodies "only with great difficulty" in some chorioallantoic lesions induced by herpes simplex virus The foregoing observations, together with the fact that sterile broth, saline and emulsions or filtrates prepared from animal tissue caused proliferation of the ectoderm at the site of inoculation, led the authors to suggest that in the case of viral infection "the cell is damaged, and in response to something diffusing from the damaged cell—either virus particles or, more probably, growth stimulating substances resulting from primary damage—neighbouring ectodermal cells proliferate"

Regarding neoplasms, it has been recognized that in the human skin some verrucæ caused by viruses[4] were characterized by the presence of intranuclear inclusion bodies[4 5] and by the appearance in the electron microscope of intranuclear crystalline arrays of particles presumed to represent virus[6] Bunting *et al* [7] and Blank[8], however, noted that the cells which contained the inclusion bodies were not seen in process of division More recently, Bloch and Godman[9] reported that the bulk of these tumours was composed of "normal appearing cells" and suggested that "epidermal cells with morphological stigmata of infection, that is inclusion bodies, have lost their capacity for mitotic proliferation" These authors proposed either that the explanation by Beveridge and Burnet regarding growth-promoting substances was correct or that the viral infection was present but morphologically and cytochemically inapparent in the light microscope

The preceding studies by light microscopy were largely dependent upon the recognition of inclusion bodies as presumptive evidence for the presence of virus It has not been definitely established, however, what relationship the inclusion bodies bear to the viral particles themselves, nor is it known whether viral development is invariably accompanied or followed by the appearance of an inclusion body in the host cell Another approach to the problem of identifying virus in specific cells was provided by the fluorescent antibody technique Noyes and Mellors[10] examined sections of rabbit papillomas stained with fluorescent antibody to the antigen of the Shope papilloma virus The antigen was found to be intranuclear and generally confined to cells of the superficial keratohyaline or keratinized layers "It was surprising," the authors commented, "that practically all the cells in the proliferating layers of the papilloma contained no antigen, for the cells in these layers make the major contribution to the growth of the papilloma " They added that "there was failure to demonstrate any viral antigen in the mitotic figures of the proliferating layers" From these results the authors advanced the postulate "that the virus is present in the germinal and the proliferating cells but exists there in an early stage of development, consisting mainly of nucleic acid and deficient in protein, and therefore non-antigenic and not demonstrable by fluorescent antibody" The possibility that virus was present but in insufficient amounts to produce fluorescence could not be excluded

With the advent of techniques suited to the preparation of thin sections for electron microscopic examination, a method was at hand for visualizing viruses in host cells at sufficient resolution to detect stages in the differentiation of structural components Of the viruses mentioned above, herpes simplex virus lends itself most readily to study in the electron microscope by virtue of the fact that it grows well both in tissue cultures and in the chorioallantoic membrane Employing the latter cell system, it had been determined previously[11] that the virus develops in the nucleus where it differentiates within characteristic aggregates of granules and appears initially as a central body enclosed by a single membrane Afterwards, a second membrane is formed Particles with a central body and two peripheral membranes appear to be the completed, infectious unit Once the stages in morphological development were recognized it became possible to identify an infected cell with considerable certainty simply by the presence of viral components, even though few in number and not fully assembled into complete virus, and by the accompanying alterations in fine structure It was decided, therefore, to re-examine the relationship of herpes simplex virus to cellular hyperplasia Accordingly, a recently isolated strain (*J M*)[12] of herpes simplex virus was transferred from tissue cultures directly to chorioallantoic membranes Three and five days after inoculation the resulting focal lesions were fixed in osmium tetroxide, dehydrated in ethyl alcohol, embedded in methacrylate and cross-sectioned at multiple levels for examination in the electron microscope Thick sections were also cut and stained for orientation by light microscopy At three days there was marked hyperplasia of the ectoderm with necrosis of the superficial cells toward the centre of the lesion The mesoderm showed œdema and infiltration by inflammatory cells and there was moderate, but definite, hyperplasia of the underlying entoderm The most striking feature revealed by the electron microscope was that only a small proportion of the ectodermal, epithelial cells contained viral components or, indeed, showed any of the characteristic changes in nuclear fine structure associated with viral multiplication At five days more cells of the ectoderm were found to be infected and necrosis had extended Contrary to expectation, however, many of the cells undergoing necrosis were devoid of virus In no instance was an infected cell encountered within the hyperplastic entoderm The foregoing suggests that under the conditions of these experiments hyperplasia is not dependent upon the intracellular presence of recognizable virus or viral components

Recently, Stoker[13], studying single HeLa cells in tissue cultures infected with herpes simplex virus, found that "none of the cells which yielded virus divided" and, further, that using tissue cultures in synchronous division it was possible to inhibit mitosis by the addition of virus even 1 hr before division was to occur If it could be shown that the mode of viral development were similar both in tissue culture and in the chorioallantoic membrane, it would not be unreasonable to assume that Stoker's observations regarding the inability of infected cells to divide would apply to the latter cell system as well Consequently, detailed comparison was made by electron microscopy between the development of the *J M* strain in chorioallantoic membranes and its development in HeLa and human amnion cells grown in tissue culture No basic differences either in the manner of viral evolution or in the morphological response of the host cell were encountered Presumably, then, in the chorioallantoic membrane, as in tissue culture, herpes simplex virus prevents mitosis of the cells in which it differentiates It would appear that some factor provided by the intact host is necessary for the hyperplasia to occur, for, as Stoker[13] has pointed out, there is little evidence to suggest that this phenomenon is associated with the infection of tissue cultures by herpes simplex virus There are insufficient data to determine whether virus also interferes with mitosis of host cells in the case of tumours, but the observations cited above regarding verrucæ and the Shope papilloma are certainly consistent with such a concept In this connexion, it is of interest that the virus encountered in the Lucké carcinoma of frogs[14] closely resembles herpes simplex virus in morphology and intranuclear site of multiplication

The purpose of this communication has been to indicate that the hypothesis advanced by Beveridge and Burnet regarding the hyperplasia associated with infections by herpes simplex virus is supported by electron microscopic examination and warrants further study with the techniques currently available. Although none of the observations herein reported exclude the possibility that a masked form of the virus is operative in neoplasia, it is equally possible that in certain neoplasms a cellular product other than the virus itself stimulates mitosis The role, then, of the initiating viral infection would be to generate or liberate this product If such were the case it would explain the apparent contradiction presented by the suggestion that a virus may inhibit mitosis, on one hand, and stimulate cellular division, on the other, for the virus could multiply at a site removed from the region of cellular proliferation Moreover, the wide variation encountered in viral assays of tumours[15] could be accounted for if the stimulus for mitosis were mediated not by the virus *per se*, but by a cellular product resulting from viral infection In these circumstances the titre of virus within the tumour would not necessarily bear a consistent relationship to the extent of mitotic activity

This study was aided by a grant from the National Foundation

[1] Dawson, J R , *Amer J Path* , **9**, 1 (1933)

[2] Burnet, F M , Lush, D , and Jackson, A V , *Aust J Exp Biol Med Sci* , **17**, 35 (1939)

[3] Beveridge, W I , and Burnet, F M , Med Res Council (Great Britain), Special Rep Ser No 256 (1946)

[4] Lyell, A , and Miles, J A R , *Brit Med J* , **1**, 912 (1951)

[5] Strauss, M , Bunting, H , and Melnick, J , *J Inf Dermat* , **15**, 433 (1950)

[6] Bunting, H , *Proc Soc Exp Biol Med* , **84**, 327 (1953)

[7] Bunting, H , Strauss, M , and Banfield, W , *Amer J Path* , **28**, 985 (1952)

[8] Blank, H , *Ann New York Acad Sci* , **54**, 1226 (1952)

[9] Bloch, D P , and Godman, G C , *J Exp Med* , **105**, 161 (1957)

[10] Noyes, W F , and Mellors, R C , *J Exp Med* , **106**, 555 (1957)

[11] Morgan, C , Ellison, S A , Rose, H M , and Moore, D H , *J Exp Med* , **100**, 195 (1954)

[12] Morgan, C , Jones, E P , Holden, M , and Rose, H M , *Virology*, **5**, 568 (1958)

[13] Stoker, M G P , Ninth Symp Soc Gen Microbiol , 142 (Cambridge Univ Press, London, 1959)

[14] Fawcett, D W , *J Biophys Biochem Cytol* , **2**, 725 (1956)

[15] Beard, J W , *Cancer Res* , **16**, 279 (1956)

FORTHCOMING EVENTS

Saturday, October 3

Association of Clinical Biochemists (joint meeting with the Association of Clinical Pathologists, at the Royal College of Surgeons, Lincoln's Inn Fields, London, W C 2), at 9 30 a m —Scientific Papers 5 p m —Annual General Meeting

Monday, October 5

Society of Chemical Industry, London Section (joint meeting with the Plastics and Polymer Group, at the Royal Institution, Albemarle Street, London, W 1), at 6 30 p m —Sir Robert Robinson, O M , F R S "The Polymerisation of Olefines Using Organo-metallic Catalysts"

Wednesday, October 7

Society for Analytical Chemistry (at the Chemical Society, Burlington House, Piccadilly, London, W 1), at 7 p m —Meeting on "Atmospheric Pollution Analysis"

Friday, October 9

Institution of Electrical Engineers (at Savoy Place, London, W C 2), at 5 30 p m —Sir Willis Jackson, F R S —Presidential Address

Society for Analytical Chemistry, Biological Methods Group (at "The Feathers", Tudor Street, London, E C 4), at 6 30 p m —Discussion Meeting on "Routine Toxicity Tests in the Control of Pharmaceuticals" opened by Mr P Andrews

Saturday, October 10

Nutrition Society (at Guy's Hospital Medical School, St Thomas's Street, London, S E 1), at 10 30 a m —Symposium on "Nutrition and the Eye"

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned

Assistant Lecturer in Agriculture—The Principal, Yorkshire (W R) Institute of Agriculture, Askham Bryan, near York (October 8)

Head of the Department of Pure and Applied Physics—The Registrar, Royal Technical College, Salford 5, Lancs (October 10)

Senior Lecturer in Mathematics, a Lecturer in Mathematics, and an Assistant, Grade "B", in Mathematics—The Registrar, Royal Technical College, Salford 5 (October 10)

Senior Lecturer (with particular interest in proteins or nucleic acids) in the Department of Microbiology—The Deputy Registrar, The University, Edgbaston, Birmingham 15 (October 14)

Reader or Senior Fellow in Biogeography in the Department of Geography, Research School of Pacific Studies, Australian National University, Canberra—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 15)

Lecturer in Psychological Medicine—The Secretary of University Court, The University, Glasgow (October 19)

Chair of Ophthalmology at the Institute of Ophthalmology —The Academic Registrar, University of London, Senate House, London, W C 1 (October 21)

Vandervell Chair of Pharmacology at the Institute of Basic Medical Sciences—The Academic Registrar, University of London, Senate House, London, W C 1 (October 22)

Lecturer in Civil Engineering at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 30)

Chair of Inorganic and Physical Chemistry in the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 31)

Lecturers (2) in Geography, and a Lecturer in Geology at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Hong Kong, October 31)

Technician in the Department of Physiological Chemistry to cut sections and apply standard histochemical tests in relation to a programme of research which is just being started—The Assistant Bursar, The University, Reading (October 31)

Fellow or Senior Fellow in Philosophy within the Department of Social Philosophy, Australian National University, Canberra—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, November 10)

Chair of Anatomy tenable in the Newcastle Division of the University—The Registrar, University Office, 46 North Bailey, Durham (November 21)

Chair of Geography in the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (New Zealand, December 15)

Head of the Department of Mathematics—The Registrar, The College of Technology, Ashley Down, Bristol 7

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London Series A Mathematical and Physical Sciences No 997, Vol 251 (11 June 1959) The Propagation of Plane Irrotational Waves Through an Elastoplastic Medium By L W Morland Pp 341–383 13*s* 6*d* No 998, Vol 251 (11 June 1959) The Rational Characterization of Certain Sets of Relatively Abelian Extensions By A Fröhlich Pp 385–425 13*s* 6*d* (London Royal Society, 1959) [186

Seventh Special Report from the Select Committee on Estimates Session 1958–59 Treasury Control of Expenditure—(Observations of the Treasury) Pp 16 (London H M Stationery Office, 1959) 1*s* net [296

Education in 1958 Being the Report of the Ministry of Education and Statistics for England and Wales Pp v+261 (Cmnd 777) (London H M Stationery Office 1959) 12*s* net [296

Government of Northern Ireland Ministry of Agriculture Leaflet No 132 Farm Planning Pp 16 (Belfast Ministry of Agriculture, 1959) [77

Hopkin and Williams, Ltd Organic Chemical Reagents—Monograph No 37 Zincon Reagent for Zinc and Mercury Metal Indicator By Eileen A Johnson and W Jablonski Pp 6 (Chadwell Heath Hopkin and Williams, Ltd , 1959) [77

Royal Institute of Chemistry Lectures, Monographs and Reports, 1959 No 1 Recent Developments in Inorganic and Organic Analytical Chemistry By Dr T S West Pp ii+41 5*s* 6*d* net No 2 Structural Analysis of Polysaccharides By Dr D J Manners Pp ii+39 5*s* net (London Royal Institute of Chemistry, 1959) [77

Government of Northern Ireland Ministry of Agriculture Supplement to Leaflet No 108 The Buckfast Abbey Strain of Honey Bee Pp 4 (Belfast Ministry of Agriculture, 1959) [77

General Register Office The Registrar General's quarterly return for England and Wales—Births, Deaths and Marriages , Infectious Diseases , Weather , Population Estimates, quarter ended 31st March 1959 (No 441, 1st Quarter 1959) Pp 28 (London H M Stationery Office, 1959) 2*s* net [77

Ministry of Labour and National Service Industrial Health a Survey of the Pottery Industry in Stoke-on-Trent—a Report by H M Factory Inspectorate Pp v+78 (London H M Stationery Office, 1959 Published for the Ministry of Labour and National Service) 5*s* net [77

Fire Protection Association Booklet No 24 Industrial Solvents and Flammable Liquids Revised, new edition Pp 24 (London Fire Protection Association, 1959) [77

Commonwealth Education The United Kingdom Contribution Prepared for the Commonwealth Relations Office and the Colonial Office by the Central Office of Information Text by Duncan Crow Pp 68+4 plates (London H M Stationery Office, 1959) 2*s* 6*d* [77

Lawes Agricultural Trust Rothamsted Experimental Station Report for 1958 Pp 283 (Harpenden Rothamsted Experimental Station, 1959) 10*s* [77

The Coal Tar Research Association Review of Coal Tar Technology, Vol 10, Part 2 (July–December, 1958) Pp ii+87–166 (Gomersal, Leeds Coal Tar Research Association, 1959) 10*s* [77

Department of Scientific and Industrial Research Torry Research 1958 on the Handling and Preservation of Fish and Fish Products Report of the Director of the Torry Research Station Pp iv+35 (Edinburgh H M Stationery Office, 1959) 2*s* 6*d* net [77

Other Countries

Laboratoire d'Astronomie de Lille Astronomical News Letter, No 94 Pp i+56 Astronomical Newsletter, No 95 Pp i+56 (Lille Laboratoire d'Astronomie, 1959) [186

Smithsonian Contributions to Astrophysics Vol 3, No 4 Some Sunspot and Flare Statistics By Barbara Bell and Harold Glazer Pp ii+25–38 (Washington, D C Government Printing Office, 1959) 20 cents [186

Ontario Research Foundation Annual Report 1958 Pp 36 (Toronto Ontario Research Foundation, 1959) [186

Official Records of the World Health Organization, No 94 First Report on the World Health Situation, 1954–1956 Pp viii+392 (Geneva World Health Organization , London H M Stationery Office, 1959) 10 Swiss francs , 17*s* 6*d* , 3 25 dollars [186

United States Department of Agriculture Agricultural Research Service Technical Bulletin No 1199 Soil Fertility Studies in Lysimeters Containing Lakeland Sand Pp 62 (Washington, D C Government Printing Office, 1959) 25 cents [186

Annals of the New York Academy of Sciences Vol 77, Article 2 Axenic Culture of Invertebrate Metazoa a Goal By Ellsworth C Dougherty and 35 other authors Pp 25–406 (New York New York Academy of Sciences, 1959) 4 50 dollars [186

Peabody Museum of Natural History, Yale University Bulletin 13 Notes on a Collection of Birds from Mindoro Island, Philippines By S Dillon Ripley and D S Rabor Pp iv+82 Postilla No 38 (April 20, 1959) Comments on Birds from the Western Papuan Islands By S Dillon Ripley Pp 17 (New Haven, Conn Peabody Museum of Natural History, Yale University, 1959) [186

Commonwealth Scientific and Industrial Research Organization, Australia Division of Fisheries and Oceanography Technical Paper No 5 The Barramundi *Lates calcarifer* (Bloch) in Queensland Waters By D J Dunstan Pp 22 Technical Paper No 6 Measurements of Light Penetration in the Tasman Sea, 1955–57 By H R Jitts Pp 26 (Melbourne Commonwealth Scientific and Industrial Research Organization, 1959) [186

United States Department of the Interior Fish and Wildlife Service Fishery Bulletin 150 Study of Age Determination by Hard Parts of Albacore from Central North Pacific and Hawaiian Waters By Tamio Otsu and Richard N Uchida Pp iv+353–363 (Washington, D C Government Printing Office, 1959) 15 cents [186

Chicago Natural History Museum Fieldiana Geology Vol 12, No 5 Pennsylvanian Invertebrates of the Mazon Creek Area, Illinois By Eugene S Richardson, Jr Pp i+79–82 30 cents Fieldiana Zoology Vol 33, No 6 Philippine Zoological Expedition, 1946–1947 Tabanidae (Diptera) By Cornelius B Philip Pp i+543–625 2 dollars Vol 39, No 28 Ticks (Ixodoidea) of Arabia, with special reference to the Yemen By Harry Hoogstraal and Makram N Kaiser Pp 297–322 65 cents Vol 39, No 29 Deep Sea Fishes from the Gulf of Mexico, *Squalogadus intermedius* (Macrouroididae) By Marion Grey Pp 323–346 50 cents (Chicago Chicago Natural History Museum, 1959) [186

Annals of the New York Academy of Sciences Vol 78, Article 1 Germfree Vertebrates Present Status By James A Reyniers and 30 other authors Pp 1–400 (New York New York Academy of Sciences, 1959) 5 dollars [186

California Department of Fish and Game Forty-fifth Biennial Report, July 1, 1956 through June 30, 1958 Pp 95 (Sacramento State of California, Department of Fish and Game, 1959) [186

European Organization for Nuclear Research Annual Report 1958 Pp 87 (24 plates) (Geneva CERN, 1959) [186

United States Department of the Interior Geological Survey Bulletin 1042–S Geology and Fluorspar Deposits, Big Four Fault System, Crittenden County, Kentucky By George C Hardin, Jr , and Robert D Trace Pp iii+699–724+plates 61 and 62 Bulletin 1045–D Core Logs from Bristol, Cadiz, and Danby Dry Lakes, San Bernardino County, California By A M Bassett, D H Kupfer and F C Barstow Pp v+415–486+plates 45–48 Bulletin 1060–C Geology and Construction-Material Resources of Pottawatomie County, Kansas By Glenn R Scott, Frank W Foster and Carl F Crumpton Pp iv+97–178+plate 5 Bulletin 1072–D Quartz Crystal Deposits of Southwestern Virginia and Western North Carolina By John B Mertie, Jr Pp iv+233–298 30 cents Bulletin 1082–B Radioactive Rare-Earth Deposit at Scrub Oak Mine, Morris County, New Jersey By Harry Klemic, A V Heyl, Jr , A R Taylor and Jerome Stone Pp iv+29–59+plate 1 50 cents Bulletin 1084–B Rapid Analysis of Chromite and Chrome Ore By Joseph I Dinnin Pp iv+31–68 20 cents (Washington, D C Government Printing Office, 1959) [186

United States Department of the Interior Geological Survey Water-Supply Paper 1353 Quality of Surface Waters of the United States 1954 Parts 9–14 Colorado River Basin to Pacific Slope Basins in Oregon and Lower Columbia River Basin Prepared under the direction of S K Love Pp xiii+426 Water-Supply Paper 1475–F Hydrologic Data, Wind River and Fifteen Mile Creek Basins, Wyoming, 1947–54 By Norman J King Pp iv+44+6 plates (Washington, D C Government Printing Office, 1959) [186

Bulletin of the Florida State Museum, Biological Sciences Vol 4, No 4 Variation in Lizards of the *Leiocephalus cubensis* Complex in Cuba and the Osla de Pinos By Albert Schwartz Pp 97–143 55 cents Vol 4, No 5 The Freshwater Decapod Crustaceans of the Apalachicola Drainage System in Florida, Southern Alabama, and Georgia By Horton H Hobbs, Jr , and C W Hart, Jr Pp 145–191 60 cents Vol 4, No 6 The Ostracods of the Genus *Entocythere* from the Lower Chattahoochee-Flint Basin With a Review of the Occurrence of the Genus in Florida, and Descriptions of Two New Species By C W Hart, Jr Vol 4, No 7 Boarfishes of the Genus *Antigonia* of the Western Atlantic By Frederick H Berry Pp 205–250 65 cents (Gainesville, Fla Florida State Museum, 1959) [186

Western Australia Geological Survey Bulletin 105, Part 2 Collie Mineral Field By G H Low Pp 135+5 plates and 13 maps (Perth Government Printer, 1959) [186

United States Department of the Interior Geological Survey Professional Paper 305–G Test Wells, Titaluk and Knifeblade Areas, Alaska By Florence M Robinson With Micropaleontologic Study of Test Wells in the Titaluk and Knifeblade Areas, Northern Alaska, by Harlan R Bergquist Exploration of Naval Petroleum Reserve No 4 and Adjacent Areas, North Alaska, 1944–53 Part 5 Subsurface Geology and Engineering Data Pp iii+377–422+plates 25–28 1 dollar Professional Paper 305–H Test Wells, Square Lake and Wolf Creek Areas, Alaska By Florence Rucker Collins With Micropaleontology of Square Lake Test Well 1 and Wolf Creek Wells, Northern Alaska, by Harlan R Bergquist Exploration of Naval Petroleum Reserve No 4 and Adjacent Areas, Northern Alaska, 1944–53 Part 5 Subsurface Geology and Engineering Data Pp iii+423–484+plates 29 and 30 1 dollar Professional Paper 305–J Test Wells, Simpson Area, Alaska By Florence M Robinson With a section on Core Analyses by S T Yuster Exploration of Naval Petroleum Reserve No 4 and Adjacent Areas, North Alaska, 1944–53 Part 5 Subsurface Geology and Engineering Data Pp iii+523–568+plates 35–38 1 25 dollars Professional Paper 314–G Succession and Speciation of the Pelecypos *Aucella* By Ralph W Imlay Pp iii+155–169+plates 16–19 (Washington, D C Government Printing Office, 1959) [186

Det Kongelige Department for Industri og Håndverk Norsk Polarinstitutt Skrifter Nr 116 The Algal Vegetation of Spitsbergen a Survey of the Marine Algal Flora of the Outer Part of Isfjorden By P Svendsen Pp 49+2 plates (Oslo Norsk Polarinstitutt, 1959) 7 Kr [77

U S Department of Commerce National Bureau of Standards Handbook 69 Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure—Recommendations of the National Committee on Radiation Protection Pp viii+95 (Washington, D C Government Printing Office, 1959) 35 cents [77

Illinois Natural History Survey Bulletin, Vol 27, Article 3 Lead Poisoning as a Mortality Factor in Waterfowl Populations By Frank C Bellrose Pp ix+235–288 (Urbana, Ill State Natural History Survey Division, 1959) 50 cents [77

Bulletin of the American Museum of Natural History Vol 117, Article 5 A Taxonomic Revision of the Spotted Skunks (Genus *Spilogale*) By Richard G van Gelder Pp 229–392 (New York American Museum of Natural History, 1959) 2 dollars [77

Koninklijk Nederlands Meteorologisch Instituut Mededelingen en Verhandelingen No 67 Klimatologische Gegevens van de Nederlandse Lichtschepen over de Periode 1910–1940 By G Verploegh Part 2 Luchtdruck en Wind , Zeegand Pp 91 7 50 florins No 73 A Theory and Method for Calculation of Wind Effects on Sea Levels in a Partly Enclosed Sea, with special application to the Southern Coast of the North Sea By Dr M P H Weenink Pp viii+111 8 florins ('S-Gravenhage Staatsdrukkerij-en Uitgeverijbedrijf, 1958) [77

U S Department of Commerce. Coast and Geodetic Survey Technical Bulletin No 4 (February 1959) Radio Telemetry Applied to Survey Problems By Richard R Ross Pp ii+7 (Washington, D C Government Printing Office, 1959) 15 cents [77

Museum of Comparative Zoology at Harvard College Breviora No 102 (April 9, 1959) A New Jamaican Galliwasp (Sauria, Anguidae) By Garth Underwood Pp 13 No 103 (April 10, 1959) Two New Species of *Eleutherodactylus* from Puerto Rico By Juan A Rivero Pp 6 No 104 (April 13, 1959) Studies on Fishes of the Family Ophidiidae 3 A New Species of *Lepophidium* from Barbados By C Richard Robins Pp 7 No 105 (April 14, 1959) *Bufo gundlachi*, a New Species of Cuban Toad By Rodolfo Ruibal Pp 14 No 106 (April 28, 1959) The Occipito-Vertebral Joint in the Burrowing Snakes of the Family Uropeltidae By Ernest W Williams Pp 10 No 107 (May 6, 1959) A Revision of the Dacetine Ant Genus *Neostruma* By William L Brown, Jr Pp 13 No 108 (May 7, 1959) Some New Species of Dacetine Ants By William L Brown, Jr Pp 11 No 109 (May 8, 1959) On the Pineal Area and Adjacent Structures of the Brain of the Dipnoal Fish, *Protopterus annectens* (Owen) By Uno Holmgren Pp 7+2 plates (Cambridge, Mass Museum of Comparative Zoology at Harvard College, 1959) [77

Proceedings of the United States National Museum Vol 109, No 3414 Flies of the Genus *Odinia* in the Western Hemisphere (Diptera Odiniidae) By Curtis W Sabrosky Pp 223–236+1 plate (Washington, D C Government Printing Office, 1959) [77

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United Nations Economic Developments in the Middle East, 1957–1958 (Supplement to World Economic Survey, 1958) Pp viii+104 (New York United Nations, London H M Stationery Office, 1959) 1 25 dollars, 9*s* , 5 Swiss francs [77

Rubber Research Institute of Malaya Annual Report 1956 Pp 79 (Kuala Lumpur Rubber Research Institute of Malaya, 1959) [77

Arctic Institute of North America Technical Paper No 3 The Vegetation of Northern Manitoba 3 Studies in the Subarctic By J C Ritchie Pp 56+8 plates (Montreal Arctic Institute of North America, 3485 University Street, 1959) 2 dollars [77

Geological Survey of Uganda Records of the Geological Survey of Uganda 1955–56 Pp ii+50+4 plates Shs 7/50 Report No 1 The Geology of Southern Mengo Explanation of Sheet $\frac{\text{North A—36}}{\text{U}}$ and part of sheet $\frac{\text{North A—36}}{\text{V}}$ By J W Pallister With an Appendix on Petrology by Dr C G B Du Bois, and a section on the Soils of Buganda by Dr E M Chenery Pp iii+124+5 maps Shs 50 (Entebbe Government Printer, 1959) [77

New Zealand Forest Service Forest Research Institute Technical Paper No 24 The Physical and Mechanical Properties of New Zealand Grown Douglas Fir By J Maddern Harris and H R Orman Pp 88+5 plates Technical Paper No 26 The Drying of *Radiata* Pine Sawn Timber Pressure Treated with Water-Borne Preservatives By J A Kininmonth Pp 32 (Wellington Director of Forestry, 1958) [77

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Editorial and Publishing Offices of "NATURE"
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ST MARTIN'S STREET, LONDON, W C 2
Telephone Number Whitehall 8831 Telegrams Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
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Telephone Number Holborn 4743

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MANAGEMENT PROBLEMS IN UNDER-DEVELOPED COUNTRIES

IN a recent broadsheet which reviewed the prospects for nuclear power, Political and Economic Planning referred to the potential market in under-developed territories for a small reactor similar to that for modestly powered gas-turbine and diesel-driven generating sets. Such a reactor, if cheap, with the advantages that it can be sited where the power is needed and its fuel requirements are small, with the consequent elimination of transmission lines and high fuel transport cost, could transform areas at present undeveloped or unexploited. Whether such reactors will actually help to raise the standard of living of millions of people who are now forced to do with little or no power and to rely on inefficient fuel burning, or human labour or on animals, does not depend entirely, however, perhaps even primarily, on the ability of the scientists and technologists of the United States, Britain or the U.S.S.R.—the only three countries at present able to provide nuclear reactors for export, the knowledge of how to work them and the necessary instrumentation and servicing—to design and manufacture such a reactor at a low enough price. It depends at least as much on the provision of efficient management in the countries where the reactors are to be used.

This aspect of technical assistance has not been entirely overlooked in earlier discussions of that broad problem, but Political and Economic Planning has now examined its implications more fully in a further broadsheet, "Management and Under-developed Territories" (No. 434, June 1, 1959)*. The broadsheet is indeed primarily concerned with the problems which confront expatriate firms already operating in such countries, one after another of which are insisting that such firms must bring local nationals into their managerial and technical staff. Technically qualified nationals, however, have been very hard to find, both for lack of local technical education and for lack of the basic education necessary to acquire technical qualifications. In principle, management positions were open to anyone capable of filling them, but in practice Europe and North America have been the only sources of supply.

The broadsheet emphasizes the close connexion between political and economic factors in the under-developed territories; but to the scientist and technologist it is of special interest for its analysis of the way in which Western firms established in such countries have sought to meet this demand and of the phases of their consequent staffing policy. Factors are emphasized which should be noted by those who proceed to such countries under schemes of technical aid, no less than by those who enter the service of expatriate firms. Particularly is this true of the concluding section of the broadsheet, which discusses the influence of the political climate in such countries and the attitude that is adopted towards Western institutions and ways of doing things. The main assumption on which Western aid to the poorer countries has so far been based—that, if enough technical knowledge and capital are injected into a country which is very deficient in both, it is on the way to becoming rich and developed—is frankly challenged.

The shortage of educational and training facilities in under-developed countries, especially in Africa, has led many firms to set up their own; but this has meant both finding young men capable and willing to attend courses of higher education, and persuading young men already receiving higher education in local or European universities that the opportunities genuinely exist. Competition for the talent available locally is keen and sometimes the supply of young men of good calibre is limited by the practice of requiring scholarship holders to enter government service for a period. Moreover, a man not fully trained to the standards of a Western concern may be, by local standards, fully equipped for a senior post.

The broadsheet naturally does not enter into the problems of promotion policy which can easily arise, but these possibilities of friction have to be considered in framing a staffing policy and they are not diminished where race and class form the basis of politics, as they do now to a large extent in under-developed countries. Political pressure towards nationalization, in the sense of increasing the proportion of nationals employed, may not allow the time required to determine a wise staffing policy and to build up a tradition of fundamental values of honesty, truthfulness and loyalty, which like the readiness to assume responsibility may require to be nurtured and strengthened in different countries in different ways. While a necessary minimum of academic knowledge may be demanded of scientific or technical staff, it would be wrong to expect the same response from the graduates of such countries as from their European counterparts. Some allowance must be made for the local environment.

Nor is it simply a matter of adapting an organization to its environment. Changes in management technique may be required, and care should be taken that expatriate staff who are selecting, training and working with 'national' colleagues develop their own powers of understanding at least to the extent of being able to comprehend the mental processes of such colleagues, to assess justly their character and ability, and to assist them in their difficulties of adjustment to their job and to their European colleagues. Moreover, as *Planning* points out, the emergence of common problems of development and the disparities in supplies of trained men between countries, and the need for the parent company to keep in close touch with the problems of local companies, encourage the development of a managerial staff with wide experience outside their own countries , and this widening of opportunities for men of all races to reach positions of responsibility will probably place a practical limit upon the employment of nationals as such in any one local company

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* *Planning*, Vol. 24, No. 434 (1 June, 1959). Management and Underdeveloped Territories. Pp. 113–130. (London: Political and Economic Planning, 1959.) 2s. 6d.

Summarizing the stages through which the staffing policies of parent firms have passed, the broadsheet notes that up to the Second World War, overseas firms were staffed largely by expatriates, who generally made careers abroad , and there was a general prejudice against business careers on the part of Western-educated nationals, even if educational facilities had been adequate for them to enter the executive ranks This was succeeded by a phase in which national talent was created where necessary, either by internal training or by the formation or support of educational opportunities outside the firm Now a third phase is emerging The arrival of the locally recruited executive has coincided with—and is partly responsible for—the rapid disappearance of the expatriate career, as distinct from the job, abroad Now, at least among the international concerns, staffing policy is developing along the lines of equipping management with international, rather than national, experience

The aim of this policy is to obtain a greater cross-fertilization of ideas through an extensive system of overseas postings during the development of the career of an executive The concept of an expatriate career is being eliminated by offering jobs abroad as an integral part of management training and promotion This new type of policy should not only improve the quality of management but also contribute to greater adaptability It clearly has implications in respect of education for management in Britain, and although it should ensure that on the Western side the weakness of rigidity is avoided, it should also be remembered that rigidity is equally dangerous where nationalism is encouraged

It is here that the broadsheet, referring to Turkey and Iraq as examples, challenges the assumption that technical aid, applied in Western manner through institutions of Western style, can alone provide all that is needed, and quotes in support Mr M Ionides's recent address, "Technical Aid the Role of the West", to the Royal Institute of International Affairs Western institutions, Mr Ionides argued, adapted to societies where the initiative comes from below, cannot fully satisfy the needs of a society where the flow of initiative is from the top downwards In particular, Western institutions are not organized to tap the immense capital resources in such countries already existing in the form of unused man-power , they can only touch the fringes where a cash-economy exists

More and more capital and technical assistance are being supplied to the centres of sophisticated Western-style economy in the under-developed countries, sharpening the contrast with the surrounding rural economy, and whetting appetites for higher standards of life Capital investment from outside, from the top downwards, cannot fill this gap and the balance of influence of the West has so far diverted the attention of these countries from their need to help to work out their own ways of filling this gap by mobilizing the reserves of labour Western-inspired ideas of industrialization naturally put the emphasis where the system works best , this attracts enterprise and initiative away from the much-needed widespread small-scale development Nor does the large-scale project which the West can provide and which most governments in these under-developed territories request, because they want to develop in the Western manner, teach the simpler methods and provide the training in them that are needed or supply where it is needed the organizing ability essential for a start It does not even provide the experience or outlook required to initiate or operate schemes which are not primarily aimed at securing profits

This is a formidable argument, and it emphasizes the close connexion between economic and political factors in the under-developed countries If it is correct, the assistance programmes sponsored by governments and international agencies may require extensive modification Deficiencies there cannot be made up by goodwill or flexibility on the part of the branches of Western industry and commerce already established in those countries Be that as it may, the prospects for the export of the small nuclear reactor should be the brighter in such a context , but the opportunities for Britain here and elsewhere will also depend on the attention given to training for management, and the quality and width of outlook and wisdom of the trained man-power which she is able to send overseas—as administrators, technologists or scientists—and whether in government or other public service or in ordinary industrial or commercial life

CLASSICS OF NUTRITION

A History of Nutrition

The Sequence of Ideas in Nutrition Investigations By Prof Elmer Verner McCollum Edited by H Bentley Glass Pp x+451 (Boston, Mass Houghton Mifflin Company, 1957) 6 dollars

The Englishman's Food

A History of Five Centuries of English Diet By the late Prof Sir Jack Drummond and Anne Wilbraham Revised, and with a new chapter by Dorothy Hollingsworth Pp 482+8 plates (London Jonathan Cape, Ltd , 1958) 36*s* net

HERE are two volumes of outstanding interest and importance It is not an exaggeration to say that each of them is indispensable to all serious research workers, and other students of nutrition

E V McCollum, now professor emeritus of biochemistry of the Johns Hopkins University, is the doyen of nutrition authorities, pre-eminent as a pioneer investigator himself, and at the same time the leading historian in this field The respect and regard in which McCollum is held throughout the world are indicated by the fact that he was among the first to be accorded the honour of election as an honorary president of the International Union of Nutritional Sciences, and that he is also to be the honorary president of the Fifth International Congress of Nutrition to be held in Washington, D.C., in 1960.

In the judgment of the present writer, an essential part of the greatness of such men as McCollum and Drummond is that they have the ability to regard science as a matter of historical development and growth, rather than as a mere catalogue of facts or a repository for items of knowledge. It is a pity that this historical outlook is not more widely encouraged to-day in our colleges and universities. All too common is the student, superficially self-satisfied, who supposes that when the lecturer turns to discuss the historical evolution of his science, rather than to present him with ready-made summaries of current information, then is the time when he can relax or quietly fall asleep. Yet the fact is that no student can hope to acquire a proper understanding of the existing teaching in his chosen sphere except by learning how the current views have come to be accepted and what is the actual foundation for them. Indeed, to the young student aspiring to become a research worker, one might go further, and say that unless he is genuinely interested in studying the bases of knowledge—that is to say, following the reasons why certain beliefs, theories or scientific explanations are held, the stages through which accepted notions have gradually travelled, in other words, their historical background—he is not likely to have the mental approach that makes a successful investigator. We may extend the argument to the teacher himself. He is a less good teacher, and a less efficient teacher, who is content to leave his student with no more than the statement that such-and-such is now the established view, and that is all there is to it. He is the better teacher, and the more stimulating teacher, who gives his pupils an explanation of the following kind: formerly certain ideas were considered well founded; but later they had to be modified in some respects because of newer knowledge and fuller understanding; and that is the reason why the presently accepted belief is so-and-so; but that nevertheless various rival opinions are often justified on any topic; and that there are always bound to remain gaps in our knowledge and room for further developments and the possibility of wider interpretations.

No doubt it is this mental approach which has served to make Prof. McCollum not only a leader in nutritional thought but also a famous experimentalist, and the instigator of so much fine work by his 'school' of colleagues and pupils. One of his own most celebrated contributions dates back to 1913–15, when he gave the first demonstration of the probable multiplicity of "rat-growth factors", and by the designations "Fat-Soluble A" and "Water-Soluble B" set the stage for the system of classifying the vitamins now familiar to all. No less influential in provoking thought and moulding opinion was his celebrated book, "The Newer Knowledge of Nutrition", the first edition of which appeared in 1918, and which may be regarded as the earliest of the modern treatises on nutrition. In a sense, "A History of Nutrition" can be considered as an up-to-date revision of "The Newer Knowledge of Nutrition". In this new work, the reader will find an impressive survey of the whole field, and one that is at the same time scholarly, well balanced, illuminated by a sound, critical judgment and a wise discrimination. The treatment is sufficiently comprehensive, in the course of its 450 pages, to cover the ground adequately and without anywhere becoming laborious, wearying or unwieldy. Much of the text is the result of careful and loving original bibliographical research by the author himself. It is certain that any future writers on nutritional history will have to turn to McCollum's new book as their starting point.

As to the new edition of "The Englishman's Food", one need say no more than that on its first publication in 1939 it immediately became the standard work on the dietary conditions of, and the food habits of, ourselves and of our ancestors during the past five centuries. Nothing covering the same ground had been available previously, or has been published since; and this second edition was sadly overdue. Miss Dorothy Hollingsworth has done her work conscientiously and well in revising the book and bringing it up to date, and has added a useful new chapter on "The Application of the Newer Knowledge of Nutrition". Unhappily, because of the increasing costs of printing, the publishers found it necessary to reduce the overall size of the book, with the result that some of the earlier chapters have had to be shortened, chiefly by the omission of quotations from historical texts, some of them of fascinating interest. Many of us will regret this; but such is the sad lot of authors to-day.

Leslie J. Harris

FLOW OF COMPRESSIBLE FLUIDS

Mathematical Theory of Compressible Fluid Flow

By Richard von Mises. Completed by Hilda Geiringer and G. S. S. Ludford. (Applied Mathematics and Mechanics: a Series of Monographs prepared under the auspices of the Applied Physics Laboratory, Johns Hopkins University.) Pp. xiii+514. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 15 dollars.

This book was originally planned by von Mises, but owing to his untimely death he was unable to complete his task. With the aid of some notes he left, Hilda Geiringer (Mrs. R. von Mises) and G. S. S. Ludford were, however, able to complete the work. The first three chapters were written by von Mises himself and the remaining two are due to the above-named authors, to whom everyone should be grateful for preserving so much of the last important work of von Mises.

The material contained in the book is intended for the research worker and the graduate student, but it should be of value to anyone making a serious study of aerodynamics. The basic theory is developed in a clear and simple way that is easy to understand. Great pains are taken to explain fully fundamental concepts and the significance of the various assumptions made in the development of the mathematical methods for the solution of certain aerodynamic problems. The concept of a specifying equation is introduced which, with the usual four equations of Euler connecting the velocity components of the flow, the pressure p and the density ρ, enables these five unknowns to be determined. The most common forms of the specifying equation are $\rho = \text{const.}$ for incompressible flow, and $F(p, \rho) = 0$ for compressible flow, where p and ρ are at all times connected by a one-to-one relation.

In scope the book is somewhat limited. Only one and two-dimensional flows are fully discussed, and in the main only problems of inviscid flow for which exact solutions have been found are considered No attempts are made to assess the practical value of these theoretical results by comparison with experiment

Chapter 1 gives the basic equations for different types of flow under various conditions and Chapter 2 is concerned with general theorems of use in the study of rotational flows, the hodograph method and the theory of characteristics Chapter 3 is devoted to one-dimensional flow and contains sections on the effects of viscosity, heat conduction, simple wave propagation, shock reflexion and shock collision A thorough presentation of the hodograph method, with a full discussion of recent advances in the theory, is included in Chapters 4 and 5 Special attention is given to the treatment of shock waves and the book ends with an article on transonic flow The main text is followed by an appendix of some forty pages of relevant and most interesting biographical and historical notes

W P JONES

THE METALLURGY OF MAGNESIUM

The Physical Metallurgy of Magnesium and Its Alloys

By Prof G V Raynor (International Series of Monographs on Metal Physics and Physical Metallurgy, Vol 5) Pp ix+531 (London and New York Pergamon Press, 1959) 75*s* net

PROF G V RAYNOR'S latest book provides the first predominantly theoretical survey of the subject of magnesium and its alloys, and it will most certainly form a valuable companion volume to those books published in recent years concerned mainly with the technological aspects of magnesium metallurgy Both students and those concerned with development in industry will welcome this authoritative work, which is presented so as to give the theory first, followed by a review with examples of the alloy systems formed by magnesium

The first part of the book (Chapters 1–7) deals with the fundamental nature of magnesium, its electronic constitution, and the effects of alloying This section contains a masterly ten-page summary of the electron theory in general, before presenting a critical account of the qualitative and quantitative studies that have been made of the electronic constitution of magnesium Magnesium is in a most interesting electronic state, and the author discusses, in a chapter on the lattice spacings of magnesium alloys, electronic interpretations of departures from Vegard's law, and lattice spacing changes due to temperature changes and to the application of tensile stress

After a description of the general alloying behaviour of magnesium, in terms of the Hume-Rothery factors of atomic size, and relative- and electro-negative valency effects, an extensive account is given of the occurrence of intermediate phases in magnesium alloys In particular, the structures of 'normal valency' compounds and Laves phases are considered in some detail, and the chapter is concluded by some pertinent observations as to why precipitation of these intermediate phases seldom leads to a high response to age-hardening in magnesium alloys

This section of the book is concluded by an account of the deformational characteristics of single crystals and polycrystalline aggregates After a fairly elementary description of edge and screw dislocations, the crystallography of slip and twinning in magnesium at room and elevated temperatures is outlined Rupture, and the development of preferred orientations, are also considered, and an account of creep characteristics concludes the chapter

The second part of the book (Chapters 8–17) describes and discusses the alloys of magnesium, considering the solute metals from the various groups of the Periodic Table in turn, stress being laid on those of present or potential importance A selected list of references is provided at the end of each chapter —the literature being reviewed up to and including 1957 Rapid reference to this part of the book would be made easier by the more generous provision of sub-headings, as the alloys in each group are discussed

A review of this nature emphasizes our ignorance of the fundamental mechanism of many technological processes, and many fields for further research are indicated The suggestion of "submicroscopic precipitates" in, for example, the creep-resistant magnesium–cerium alloys will certainly whet the appetite of electron microscopists There is, in fact, rather a dearth of photomicrographs in the book (there being only two sets), doubtless due to the high cost of their production The value of the second set of micrographs is also reduced by the absence of any supplementary information—magnification, preparation, etc

An account of the systems formed with gaseous elements or compounds concludes the review, an interesting discussion of the oxidation characteristics of the metal being included here The final chapter summarizes the influence of alloying on the mechanical properties of magnesium The book contains more than 200 diagrams—the phase diagrams being particularly well produced This robust, well-bound volume will surely grace the shelves of students and research workers alike for many years to come

J W MARTIN

BIOLOGICAL PROPERTIES OF PHENOLS OF PLANT ORIGIN

The Pharmacology of Plant Phenolics

Proceedings of a Symposium held at Oxford, April 1958 Edited by J W Fairbairn Pp ix+151 (New York Academic Press, Inc , London Academic Books, Ltd , 1959) 6 dollars , 30*s*

IT is not often that an attempt is made to present within the space of 150 pages a review of the biological properties of such a wide variety of chemical substances as the plant phenolics It can indeed be argued that such a review can be of little value because the plant phenolics comprise a miscellaneous assortment of substances having nothing in common beyond the presence of an aromatic hydroxyl group, and some may feel that the choice of subject-matter has been made even more arbitrary by the inclusion of the chapter on adrenaline, noradrenaline and 5-hydroxytryptamine, since these substances are not of plant origin and owe their characteristic pharmacological properties to the presence of an amino-group rather than to the presence of a phenolic group

Even if the fundamental pattern of this book—the proceedings of a symposium held in Oxford last year—is regarded as slightly illogical, it represents, nevertheless, an important contribution to the field of structure–activity relationships

The book begins with a concise authoritative chapter by J H Burn on adrenaline and other nitrogen-containing phenols mainly of animal origin, and is followed by another chapter, by R T Williams, summarizing what is known concerning the fate of phenolic compounds in the body In the third chapter W B Whalley discusses the toxicity of plant phenolics as a group, providing a useful introduction to the next five chapters which describe in more detail the action of specific groups of compounds J W Fairbairn, who is also the general editor, discusses the anthraquinones, and J D Biggers genistein and related compounds which exhibit œstrogenic activity and, in a separate chapter, hypericin and similar compounds that cause photo-sensitization Three chapters are devoted to the flavonoids and their effect on capillary blood flow In the first M F Lockett considers the evidence in support of the view that they act directly on capillary permeability and tensile strength, while in the other two F Deeds and J Lavollay and J Neumann present the case for indirect activity, mediated through adrenaline and ascorbic acid The last two chapters of the book deal with plant phenolics in food and wine, J Masquelier directing attention to the high bactericidal activity of some wines and E C Bate-Smith concluding the book on the reassuring note that most of the phenolic constituents of foods are fortunately pharmacologically inert

The book is well printed and free from errors Its value is greatly enhanced by the list of references given at the end of each chapter and by summaries of the discussions that took place at the symposium Most pharmacologists, organic chemists, biochemists and pharmacists will find much of interest and value in this volume F A Robinson

ORCHARD SCIENCE

Tree Fruit Production

By James S Shoemaker and Benjamin J E Teskey Pp vii+456 (New York John Wiley and Sons, Inc , London Chapman and Hall, Ltd , 1959) 56*s* net

ADVANCES in plant physiology, in plant breeding, in plant protection and in the knowledge of plant toxicants, are to-day being paralleled by advances in crop husbandry and soil management, and in tree shaping and growth control The impact of these advances on commercial fruit-growing is being influenced by economic considerations While the facets are the major concern of the appropriate specialist, who may be quite ignorant of the over-all subject of pomology, the teacher of pomology, as the term is now generally understood, must be keenly aware of the progress being made in all the branches of fundamental science that affect his subject and be willing and able to incorporate the new knowledge in turn into his teaching and demonstrations

With specialist fruit-crop research stations in many parts of the world now more or less well staffed and equipped, new knowledge, supposedly new knowledge or old knowledge recapitulated is being published so plentifully as to embarrass alike both teacher and taught From time to time experienced teachers give us the benefit of their selection from among this wealth of material and, if they are competent teachers and are critical in their selection, the result is a good book

Dr Shoemaker is such a teacher, and this book, written in collaboration with Dr Teskey, bears evidence of a wide-ranging but careful selection of subjects (there are more than 800 references, the majority of them within the past 20 years) and a commendable compression of the essential material , an 11-page double-columned index makes for easy reference Text-books on husbandry are difficult to illustrate, and this one is no exception , line drawings and diagrams, like those on grafting, are clear and good , photographs of plantations and many field operations, like picking and pruning, do not reproduce well

The authors have covered apples, pears, cherries and plums, all of which interest us in the British Isles Peaches, apricots, nectarines and quinces should interest our Western and Southern European neighbours, and citrus fruits are also the concern of the countries bordering the Mediterranean sea The authors were not catering for this wide public but aimed at producing an up-to-date guide to current orchard and fruit plantation practice for use in Canada and America Nursery practice, site selection and modification, planting considerations and varieties for particular purposes are all discussed, together with tree nutrition, pest and disease control, soil and plantation management and harvesting as well as handling and storage There is a special chapter on the cultivation of dwarf apples and pears, evidently in response to demands from students for information on this subject For a long time European growers have been particularly expert in controlling tree size and yield, and American growers may face many difficulties in adapting European methods to their needs

Though essentially written for students this book contains much that will interest fruit growers and their advisors in many parts of the world

H W Miles

SCHIZOPHRENIA

Schizophrenia· Somatic Aspects

Edited by Derek Richter Pp viii+181 (London and New York Pergamon Press, 1957) 40*s* net

Chronic Schizophrenia

By Thomas Freeman, John L Cameron and Andrew McGhie Pp xi+158 (London Tavistock Publications, Ltd , 1958) 21*s* net

A New Approach to Schizophrenia

By Julius I Steinfeld Pp 159 (London Hutchinson Medical Publications, Ltd , 1958) 21*s* net

SCHIZOPHRENIA is a major cause of disability in most parts of the world In countries for which statistics are available it constitutes approximately half the chronic population of mental hospitals Almost one in every hundred persons is fated to suffer from the disease, and the majority, particularly the men, break down in the second and third decades of life The wastage of human life and the amount of suffering and social dislocation it causes are probably greater than that due to any other single disease The International Congress of Psychiatry held two years ago was devoted wholly to this subject Its deliberations served largely to bring home the failure to achieve any substantial advance in knowledge of its causation since the condition was first described by Kraepelin and later further defined by Bleuler.

These three books reflect three of the commoner types of theoretical approach adopted in the vast literature on the subject: the organic or somatic approach, the psycho-analytic and the eccentric.

The monograph edited by Derek Richter contains a number of essays dealing with the present state of knowledge in relation to the anthropometric aspects and the electroencephalographic, neuropathological and endocrinological observations. There is a study of metabolic changes in recurrent schizophrenia, one on the effects of drugs introduced into the cerebral ventricles, a paper on the therapeutic effects of drugs and on the symptoms induced by mescaline which are at times scarcely distinguishable from those observed in schizophrenics. One paper attempts to reconcile the observations suggesting that a mutant gene is the primary cause with those that imply that environmental causes are of some importance. The picture of present knowledge that emerges is scarcely encouraging. Schizophrenics differ as a group from normal controls in respect of body build and in relation to a whole range of biochemical tests. There is some evidence that histologically demonstrable changes occur in some parts of the brain. The schizophrenic also responds abnormally to a wide range of drugs. But all these changes are without specificity and the degree of overlap with normal control groups is so great for all anomalies that they are rendered useless for purposes of diagnosis. In many instances uncertainty remains as to whether we deal with manifestations of causal agents, with effects of the disease or the results of long periods of institutional care. Moreover, with the possible exception of Gjessing's celebrated work on disturbances of nitrogen metabolism in the very small group of cases of periodic catatonia, none of the differences found has been so far successfully exploited to advance knowledge in relation to ætiology, prognosis or classification. The one hard fact which shines clear and constant through this nebulous matrix of data is that the hazard for developing schizophrenia in the sib of a schizophrenic is some ten times that for a member of the general population; for his child sixteen times, for a dizygotic twin some thirteen times and for a monozygotic twin between seventy and eighty times as great. Although its significance remains unclear, the recently demonstrated difference in the chance of being admitted to mental hospital with schizophrenia in the different social classes has been already confirmed in a number of countries and promises to be an equally clear and consistent observation.

The dismally slow rate of progress along organic lines has led some workers to throw up the sponge and to devote their energies to the uncovering of meaningful associations in the mental life of the schizophrenic. The theoretical framework for this kind of endeavour is usually provided by one of the schools of psycho-analysis. The stringent controls considered essential for scientific inquiry to ensure that findings are not interpreted in accordance with preconceived theory are often regarded as inapplicable or irrelevant. The psychoanalytic exploration and treatment of schizophrenia has in recent years attracted enthusiastic adherents; it had previously been considered therapeutically useless.

The book by Dr. Freeman and his colleagues deals with observations and treatment inspired by psycho-analytic teaching and carried out in two groups of chronic schizophrenic patients. They concur in the view expressed by Federn that the essential psychological disturbance produced by this disorder is a weakening of the functions of the ego leading to a breakdown of its boundaries and failure to differentiate between self and non-self or environment. Variations in the form of the disease are attributed to the degree of ego function. The disorders of thought, affect and volition and the disturbances of perception characteristic of the schizophrenic are all considered to stem from the change in the experience of the self. Although this is regarded as the essential psychological disturbance, the problem of ætiology is left open. The therapeutic programme based on these findings is directed towards ego-building, which includes fostering closer and more durable relationships between patients and nurses, efforts to communicate at the patient's own archaic level, and, on the assumption that stimulation of the body enhances awareness of the self, such things as stroking the face and making a ceremonial of bath-time. The effects of these measures on ward atmosphere and on individual patients are said to have been gratifying but no clear analysis of the results is given.

Exploration of the inner life of the schizophrenic is of value as a form of inquiry, and a premature insistence on quantitative data in a field such as this can prove stultifying to new ideas. Some Continental psychiatrists who do not subscribe to psycho-analytic teaching have testified to the beneficial effect exerted by this kind of endeavour when initiated in a mental hospital where formerly the predominant influence was the so-called "objective" psychiatry, the adherents of which at times unwittingly treated the patient almost as if he had been an inanimate object.

However, the scientific merit of theories cannot be decided by pragmatic considerations. The breakdown of ego boundaries here described as the source of all psychological disturbances in schizophrenia is equally applicable as a metaphorical description for the mental disturbances in delirium, dementia, dreaming and depersonalization, which are quite different phenomena. Moreover, a very large number of unifying explanations have now been proposed, all claiming to be illuminating for the understanding and efficacious in the treatment of schizophrenia. Thus Dr. Steinfeld's book states that oral frustration in infancy is the root cause. Excessive hunger in early life over-strains the vegetative mechanisms, which may then remain in a state of high catheris through life. He has more than a suspicion, for reasons not made explicit, that in carcinomatosis similar mechanisms may be at work.

As in other fields of scientific inquiry, insights, and 'intuitive leaps' in psychiatry have to be treated with respect—those of others no less than one's own—which is precisely why none deserves serious consideration until its relevance and heuristic value have been objectively demonstrated so far as possible.

Many observations cited in the first book suggest that the slow progress of scientific inquiry in this field may be partly due to the heterogeneity of schizophrenia. Recent genetic, clinical and epidemiological data show promise for discovery of the natural lines of division between the different variants in the syndrome. When this has been achieved, progress in the definition of causal agents in schizophrenia, whether psychogenic or physiogenic, is likely to be accelerated.

Martin Roth

The World of Learning 1958–59

Ninth edition Pp xiii+1139 (London Europa Publications, Ltd , 1958) 130*s* net.

THE ninth edition of the "World of Learning", which is now well established as a valuable guide to scientific, cultural and educational institutions throughout the world, follows the pattern of its predecessors, but is considerably enlarged, due to the world-wide expansion of scientific and technological research, and to the recent foundation of many universities and technical colleges in the relatively undeveloped countries

The first section, devoted to Unesco, describing its aims, programmes, organization and finance, is followed by a short account of the work and structure of the International Council of Scientific Unions and other international organizations, together with brief statements of their objects and the names of their principal officers

The remainder of the book is divided alphabetically into the various countries of the world (by their names in English) The arrangement of entries for Great Britain—which occupy 86 pages—affords an indication of the scope of the work learned societies and professional associations , research institutes , libraries , museums and art galleries , universities and university colleges , centres of adult and technical education , schools of art, music and dramatic art , agricultural colleges , and education trusts In general, the entry for each institution includes its address, the names of its leading officials , and for each university a complete list of professors is given Where applicable, the titles of any publications issued by the body concerned are also listed The entry for the U S S R , which occupies 38 pages, lists the members of the Soviet Academy of Sciences and the heads of its various departments and research organizations Forty-one Russian universities are listed, with their faculties, but the names of their professorial staffs are not given , a long list of the very numerous institutions of higher education and research of the Soviet Union are, however, included The largest single entry, comprising 190 pages, relates to the United States of America

There is an alphabetical index of institutions, but none of persons, mentioned in the book

Handbook of the Rubi of Great Britain and Ireland

By the late W C R Watson Pp xi+274 (50 figures) (Cambridge At the University Press, 1958) 63*s* net

PROFESSIONAL systematists tend to be superior about brambles and batologists, partly because, in Britain at least, batology has been primarily an amateur study, but perhaps more particularly because the *Rubi* refuse to comply with orthodox ideas, and, like slum children in a respectable neighbourhood, are a perpetual affront to the dignity of those who value orderliness and correct behaviour It was perhaps vain to hope that Mr Watson's long-awaited monograph would finally set the seal of respectability upon this sprawling and troublesome group, but the opinions of one who studied the brambles assiduously for more than forty years must be given careful consideration Every line of this admirably produced monograph bespeaks seriousness of purpose, integrity and industry, and the wealth of Watson's knowledge is testified time and time again throughout the book, though perhaps most strikingly in the introductory pages What a pity the author did not live to publish a separate and more elaborate essay on brambles and bramble classification, for it must be confessed that his generalizations and *obiter dicta*, though perhaps controvertible, are vastly more intriguing than his detailed and somewhat desiccating descriptions of the three hundred and ninety-one species said to occur in Britain Admittedly everything possible has been done, in keys, descriptions and illustrations, to convey the author's mature conclusions to the reader, but language and art have their limitations, and the fond hope that the book will "furnish the means of identifying every native species met with" is perhaps a shade too optimistic The unenlightened sees only one blackberry , the observant possibly half a dozen, but only the specialist, with twenty or more years experience behind him, can hope to recognize the majority of the species included in this book , and then—who knows—the specialist may wish to add a further hundred species of his own to the British list, for one suspects that *Rubus* species, like parallel lines, can be extended to infinity R D MEIKLE

Annual Review of Entomology

Vol 4 Edited by Edward A Steinhaus in association with Ray F Smith Pp viii+467 (Palo Alto, Calif . Annual Reviews, Inc , 1959 Published in co-operation with the Entomological Society of America) 7 dollars

A REVIEWER always likes to imagine editors and authors feverishly scanning his Olympian judgements and then departing to brood on the error of their ways While experience must inevitably destroy this pleasant picture, it is gratifying to notice the present coincidence Volume 4 of the "Annual Review of Entomology" fulfils almost entirely the critical requirements suggested in reviews of the previous volumes in these columns Thus we have a volume broadly based not only in subject-matter but also in the geographical distribution of its contributors , a review which includes several papers on subjects at the 'growing-points' of entomology—insect physiology, ecology and control—and finds space for one or two on the borderline of other sciences, such as the role of insects as disease vectors In fact, it would be a dull entomologist indeed who could not find something of interest or profit in the present volume

If this standard is maintained then critical interest can be transferred to a higher level , although in the present volume the general concept is good, a few of the individual treatments fall short of this standard and degenerate into the 'card-index' type of review Review articles of the highest quality must not only present a selection—for in these days that is all it can be—of the literature but must also strive to produce some stimulating and if possible enlightening synthesis from it

In matters of detail the present volume is as well produced as its predecessors and at last each article has a bibliography in alphabetical order , the index is good, although several misprints and incorrect page numbers appear here

But these are small matters compared with the solid value and interest of this volume , the Entomological Society of America, which this year terminates its financial obligations to the "Review", must be congratulated on bringing into being a work which, on present standards, will be of great value to every entomologist P T HASKELL

RADIOCARBON DATING OF PREHISTORIC WOODEN TRACKWAYS

By DR H GODWIN, F R S , and DR E H WILLIS
University Sub-department of Quaternary Research, Botany School, Cambridge

THE purpose of building corduroy tracks is to avoid detours, and prehistoric examples of these wooden structures have been preserved by continuous water-logging It is not surprising, therefore, that increased wetness of climate should have caused many former routes to be flooded, and have induced first the construction and then the preservation of wooden trackways Thus there is an expectation that, were it possible to determine the age of a number of trackways, their ages would be grouped at distinct periods of climatic deterioration

Corduroy tracks, however, have not been studied typologically, and apart from axe-marks on the timber and the chance of associated archæological finds, they have been very difficult to date, until the advent of pollen-analysis, and, more recently, of radiocarbon dating

Both techniques have been applied to the problem of dating several of the wooden trackways revealed in recent years by peat-cutting in the derelict raised bogs of the Somerset Levels Some of these have been described already[1], and descriptions of others are being prepared for publication (*Phil Trans Roy Soc Edinburgh*) They run between the Mendip and the Polden Hills and the low islands that project through the intervening flat lowlands of the Glastonbury Levels

The six Somerset trackways so far dated, and also certain associated wooden platforms, all occur at a comparable stratigraphic horizon in the bogs This is at the surface of a very dark, highly humified *Sphagnum–Calluna–Eriophorum* peat, and its junction with a *Cladium–Hypnum* peat The lower peat is indicative of the growth of heather-clad bogs receiving water only as rain or snow, in a condition of arrest or slow growth their gentle convex surfaces could easily have been traversed on foot and offered little obstacle to passage across the levels The overlying *Cladium–Hypnum* peat by contrast points unmistakably to flooding by calcareous water from the big catchment area of the Mendips and Polden Hills Such flooding imposed very circuitous routes between one hill ridge and another and the evidence suggests that the wooden trackways were built in consequence of the flooding and that their preservation was ensured by its continuance

Several of the trackways were also shown to be close to the same pollen-analytic zone-boundary, and upon this evidence it was suggested that the tracks were probably built about the transition between the Bronze Age and the Iron Age This supposition was strengthened by the occasional discovery upon the timber of the markings of the small thick axes of Late Bronze Age type, and by the recovery of two bronze spearheads at comparable stratigraphic levels, one of the Late Bronze Age and the other of late Middle Bronze Age

Radiocarbon dates have now been obtained for the wood of the trackways and also of the peat in which they are embedded The assays were made with carbon dioxide at 2 atmospheres pressure in a copper proportional counter of about 2-litres volume[2]

Table 1 DATING OF WOOD FROM TRACKWAYS*

		Years B P
Q 52	Meare Heath track (Bulleid's)	2840 ± 110 2850 ± 110
Q 39	Shapwick Heath track (Foster's)	2470 ± 110
Q 308	Westhay track (Sandford's)	2800 ± 110
Q 306	Blakeway Farm track	2600 ± 110
Q 7	Vipers track (Dewar's A)	2520 ± 110
Q 312	Vipers track (Dewar's A)	2630 ± 110
Q 313	Nidons track (Dewar's B)	2585 ± 120
Q 311	Vipers platform	2410 ± 100 2640 ± 110

* For fuller information on the provenance of the samples see ref 3

It will be seen that these all lie between 450 and 900 B C , which is certainly Late Bronze Age in this part of Britain The datings are supported by those of the associated peat

Table 2 DATING OF PEAT ASSOCIATED WITH TRACKWAYS

		Years B P
Q 53	Meare Heath track—subjacent peat	3230 ± 110
Q 44	Shapwick Heath track—subjacent peat	3310 ± 110
Q 309	Blakeway Farm track—subjacent peat	2790 ± 110
Q 316	Nidons track—peat at track level	2590 ± 120
Q 318	Nidons track—subjacent peat	2642 ± 120
Q 319	Nidons track—subjacent peat	2482 ± 120
Q 317	Nidons track—superjacent peat	2628 ± 120

Whereas the results from Nidons track suggest close contemporaneity between the track itself and adjacent peat, at the other sites the greater age of the underlying peat supports the field evidence that some erosion or wastage of the peat surface had occurred before the trackways were constructed

As long ago as 1906 a monoxylous boat had been recovered from the bog deposits near Shapwick Station, but under conditions that did not allow any dating or reference to a stratigraphic horizon It was apparent that it could not have been embedded while the bogs were covered by heather and cotton-grass and it seemed likely that it related to a substantial flooding period The curator of Taunton Castle Museum, where the boat is now preserved, kindly provided enough wood for the following radiocarbon assay

Q 357 Shapwick boat 2305 ± 120 years B P

It will be seen that this assay places the boat within the Early Iron Age, so that it is younger than the wooden trackways and indeed corresponds in age with the *Cladium–Hypnum* peat of the major flooding episode of this time

There is a good deal of evidence in various parts of north-western Europe that about 600 B C there was in progress a change of climate towards increased rainfall and lower temperatures It has been made the boundary between the Sub-boreal and Sub-atlantic climatic periods , it is an important pollen-zone boundary and is often marked by 'recurrence-surfaces' in peat bogs In view of the likelihood that this climatic change was also widespread in Britain it is interesting to append the radiocarbon dates from three further wooden trackways that we determined.

Table 3. TRACKWAYS OUTSIDE SOMERSET

		Years B.P.
Q 310	Fordy—Little Thetford, Cambs.	2560 ± 110
Q 77	Brigg, Lincs.[5]	2552 ± 120
Q 68	Kate's Pad, Pilling, Lancs.	2760 ± 120

It was already known from associated prehistoric finds that the Brigg trackway clearly belonged to the Late Bronze Age to Early Iron Age transition. Pollen-analytic evidence and a single sherd from the Fordy trackway had already suggested a similar age for that structure. It is now strikingly evident that indeed all the trackways belong to the one archæological period.

Of course, prehistoric trackways were built at other periods than this, and the Groningen laboratory has dated an Irish example as follows:

GRO 272 Corlona, Co. Leitrim 3395 ± 170 years B.P.

None the less, the consistency of the English results is striking and strongly underlines the importance of carefully recording and dating these unregarded prehistoric monuments.

[1] Clapham, A. R., and Godwin, H., *Phil. Trans. Roy. Soc.*, B, **233**, 233 (1948).

[2] Godwin, H., Walker, D., and Willis, E. H., *Proc. Roy. Soc.*, B, **147**, 352 (1957).

[3] Godwin, H., and Willis, E. H., *Amer. J. Sci.*, Radiocarbon Supp., **1**, 63 (1959).

[4] Mitchell, G. F., *J. Roy. Soc. Antiq. Ireland*, **88**, 49 (1958).

[5] Smith, A. G., *Proc. Prehist. Soc.*, **24**, 78 (1958).

A NEW FOSSIL SKULL FROM OLDUVAI

By Dr. L. S. B. LEAKEY

Coryndon Museum, Nairobi

On July 17, at Olduvai Gorge in Tanganyika Territory, at Site *FLK*, my wife found a fossil hominid skull, at a depth of approximately 22 ft. below the upper limit of Bed I. The skull was in the process of being eroded out on the slopes, and it was only because this erosion had already exposed part of the specimen that the discovery was possible. Excavations were begun on the site the following day and continued until August 6. As a result, an almost complete skull of a hominid was discovered. This skull was found to be associated with a well-defined living floor of the Oldowan, pre-Chelles-Acheul, culture.

Upon the living floor, in addition to Oldowan tools and waste flakes, there were the fossilized broken and splintered bones of the animals that formed part of the diet of the makers of this most primitive stone-age culture. It has not yet been possible to study the fauna found on this living floor; but it can be said that it includes birds, amphibians, reptiles such as snakes and lizards, many rodents and also immature examples of two genera of extinct pigs, as well as antelope bones, jaws and teeth.

It is of special importance to note that whereas the bones of the larger animals have all been broken and scattered, the hominid skull was found as a single unit within the space of approximately one square foot by about six inches deep. Even fragile bones like the nasals are preserved. The expansion and contraction of the bentonitic clay, upon which the skull rested and in which it was partly embedded, had resulted, over the years, in its breaking up into small fragments which have had to be pieced together. The bones, however, are not in any way warped or distorted. A large number of fragments still remain to be pieced together.

This very great difference between the condition of the hominid skull and that of the animal bones on the same living floor (all of which had been deliberately broken up) seems to indicate clearly that this skull represents one of the hominids who occupied the living site; who made and used the tools and who ate the animals. There is no reason whatever, in this case, to believe that the skull represents the victim of a cannibalistic feast by some hypothetical more advanced type of man. Had we found only fragments of skull, or fragments of jaw, we should not have taken such a positive view of this.

It therefore seems that we have, in this skull, an actual representative of the type of 'man' who made the Oldowan pre-Chelles-Acheul culture.

This skull has a great many resemblances to the known members of the sub-family of Australopithecinae. Some scientists recognize only one genus, namely, *Australopithecus*, and treat Broom's *Paranthropus* as a synonym; others consider that the demonstrable differences are of such a nature that both genera are valid. Personally, having recently re-examined all the material of the two genera, in Johannesburg and Pretoria, I accept both as valid.

The Olduvai skull is patently a member of the sub-family Australopithecinae, and in certain respects it recalls the genus *Paranthropus*. In particular, this is the case in respect of the presence of the sagittal crest, the great reduction in the size of the canines and the incisors, the relatively straight line of these teeth at the front of the palate, the position of the nasal spines and the flatness of the forehead. In certain other characters, the new skull resembles more closely the genus *Australopithecus*, for example in respect of the high cranial vault, the deeper palate and the reduction of the upper third molars to a size smaller than the second, all of which are features to be found in *Australopithecus* but not in *Paranthropus*.

The very close examination and direct comparisons which I have personally made in South Africa have convinced me that, on the basis of our present state of knowledge, the new skull from Olduvai, while clearly a member of the Australopithecinae, differs from both *Australopithecus* and *Paranthropus* much more than these two genera differ from each other.

I am not in favour of creating too many new generic names among the Hominidae; but I believe that it is desirable to place the new find in a separate and distinct genus. I therefore propose to name the new skull *Zinjanthropus boisei*. This generic name derives from the word 'Zinj', which is the ancient name for East Africa as a whole, while the specific name is in honour of Mr. Charles Boise, whose constant encouragement and financial help ever since 1948 have made this and other important discoveries possible. I would also like to acknowledge the generous help received, from time to time, from the Wenner-Gren Foundation and the Wilkie Trust.

The following is the preliminary diagnosis of the new genus and the new species :

Zinjanthropus gen. nov. :

Genotype : a young male with third molars not yet in wear and sutures relatively open, from *FLK* I, Olduvai.

A new genus of the Hominidae, sub-family Australopithecinae, which exhibits the following major differences from the genera *Australopithecus* and *Paranthropus* :

(*a*) in males a nuchal crest is developed as a continuous ridge across the occipital bone ;

(*b*) the inion, despite the great evidence of muscularity, is set lower (when the skull is in the Frankfurt plane) than in the other two genera ;

(*c*) the posterior wall of the occipital bone rises more steeply to form, with the parietals, a very high-vaulted posterior region of the skull ;

(*d*) the foramen magnum is less elongate and has a more horizontal position than in *Australopithecus* (in the crushed skulls of *Paranthropus* it is not possible to be quite sure of the plane of the foramen magnum) ;

(*e*) the presence of a very massive horizontal ridge or torus above the mastoids. This is much more marked than the normal type of supra-mastoid crest ;

(*f*) the mastoids are more similar to those seen in present-day man, both in size and shape ;

(*g*) the presence of a strong wide shelf above the external auditory meatus, posterior to the jugal element of the temporal bone ;

(*h*) the shape and form of the tympanic plate, whether seen in *norma lateralis* or in *norma basalis*. In this character the new skull has similarities with the Far Eastern genus *Pithecanthropus* ;

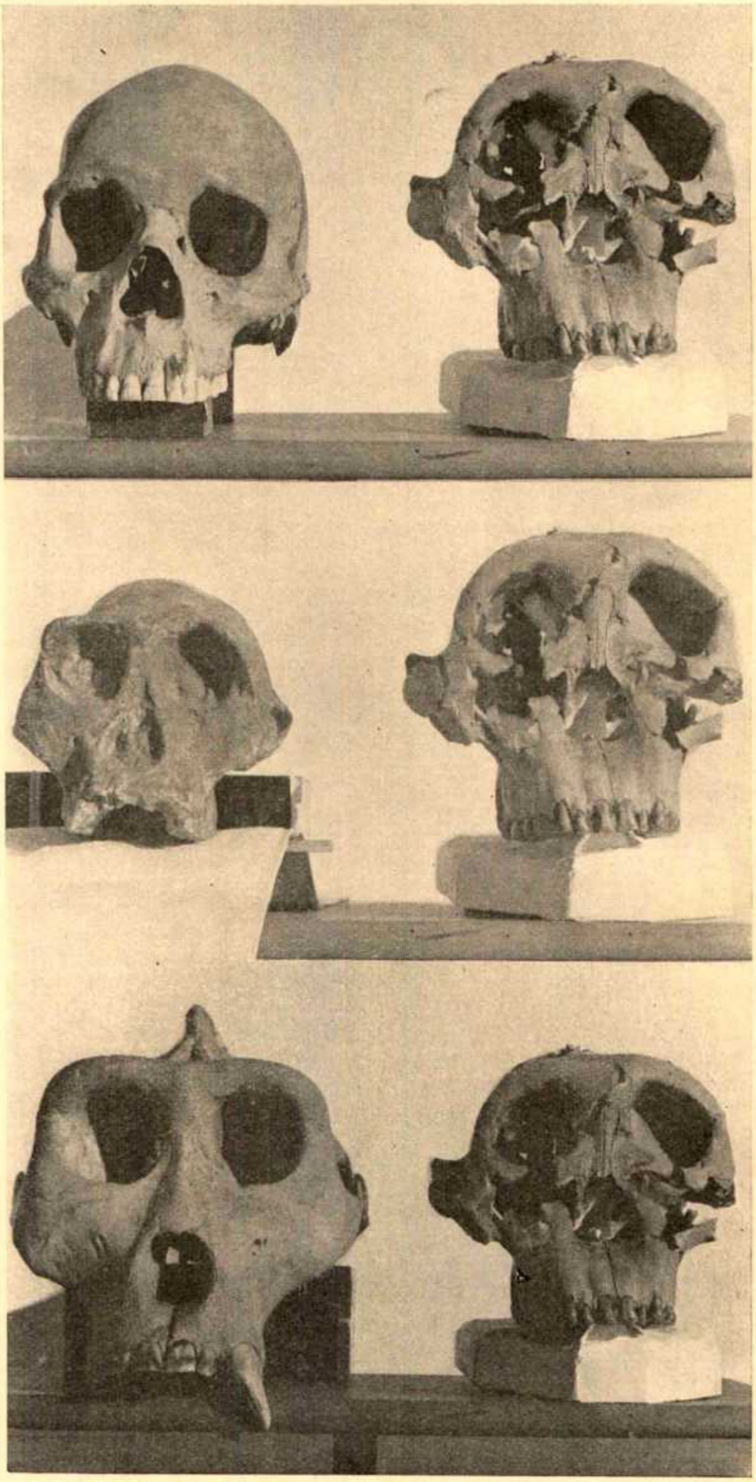
(*i*) the very great pneumatosis of the whole of the mastoid region of the temporal bones, which even invades the squamosal elements ;

(*j*) the massiveness of the jugal element of the temporal bone relative to the total size of the temporal bone ;

(*k*) the way in which the parietals rise almost vertically behind the squamous elements of the temporal before bending over to become a dome ;

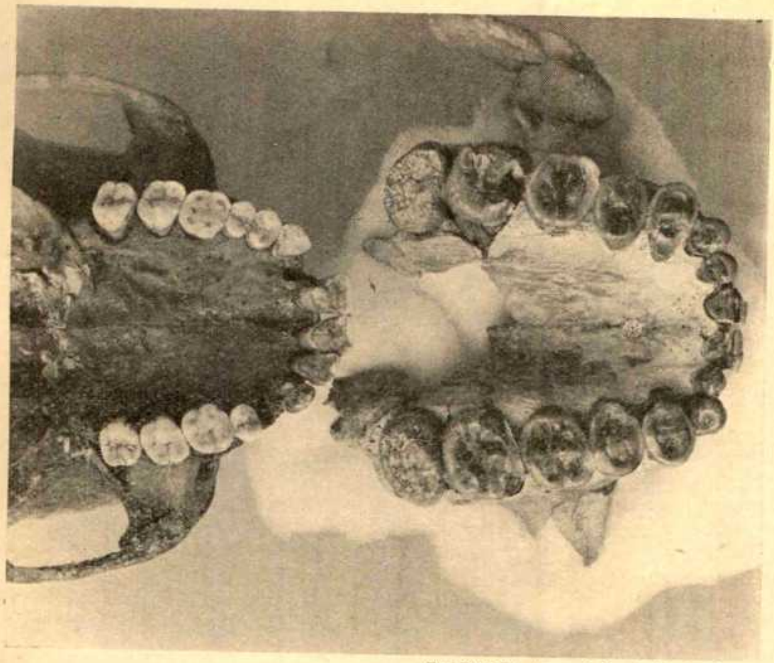
(*l*) the relative thinness of the parietals in comparison with the occipitals and the temporals ;

(*m*) the very prominent and keeled anterior margin of the crests on the frontal bone for the anterior segment of the temporal muscles in the region of the post-orbital constriction (even the most



Des Bartlett–Armand Denis Production

Fig. 1. *Above* : The new skull compared with the skull of an Australian aboriginal. Note the very long face, the architecture of the malar region, the unusual nasal bones, the torus above the mastoid, the sagittal and nuchal crests. *Middle* : The new skull compared with a cast of the most complete adult of *Australopithecus*. Note the difference in the size and shape of the face, the shape of the tympanic plate, the low position of the inion, the huge mastoid, as well as the difference in the shape of the malar region and the supra-orbital area. *Below* : The new skull seen next to that of a gorilla



Des Bartlett–Armand Denis Productions

Fig. 2. The palate of the new skull compared with that of an East African native

muscular male *Paranthropus* exhibits nothing comparable) ;

(*n*) the very unusual position of the nasion, which is on the most anterior part of the skull, instead of being behind and below the glabella region ;

(*p*) the very great absolute and also relative width of the inter-orbital area, with which may be associated the shape of the nasal bones, which are much wider at the top than at their inferior margin ;

(*q*) the whole shape and position of the external orbital angle elements of the frontal bone ;

(*r*) the very deep palate which is even more markedly like that of *Homo* than in *Australopithecus*, and is quite unlike the form seen in *Paranthropus*, except in respect of the more or less straight canine-incisor line which has already been commented on, as a character recalling *Paranthropus* ;

(*s*) the conformation of the malar-maxillary area of the cheek. In all known members of the genera *Australopithecus* and *Paranthropus* there is a buttress of bone which runs down from the malar towards the alveolar margin of the maxilla in about the region of the fourth premolar ; in *Zinjanthropus* this buttress is wholly absent and the form of architecture of this region is that which is found in *Homo* ;

(*t*) the very great area of muscle attachment on the inferior margin of the malars ;

(*u*) the relatively greater reduction of the canines in comparison with the molar–premolar series than is seen even in *Paranthropus* ; where it is a marked character.

Zinjanthropus boisei sp. nov.

A species of *Zinjanthropus* in which the males are far more massive than the most massive male *Paranthropus*. The face is also excessively long. Males have a sagittal crest, at least posteriorly. Upper third molars smaller than the second.

The above is only a preliminary diagnosis of the genus *Zinjanthropus* species *boisei*. It is recognized that, if and when further material is found, the diagnosis will need both enlarging and possibly modifying.

The whole question of generic value is one which is relative. There are some who maintain that *Australopithecus* and *Paranthropus* are not generically distinct, and who will wish to treat *Zinjanthropus* as a third, but less specialized, species of a single genus ; but the differences seem to be too great for this.

I must now turn to the absolute and relative geological age of the new skull. As stated earlier, *Zinjanthropus* comes from Olduvai Gorge, about 22 ft. below the upper limit of Bed I. It was found in association with tools of the Oldowan culture, on a living floor and with associated fauna.

In the past it has been customary to regard Olduvai Bed I as a part of the Middle Pleistocene, not differentiating it from Bed II. During the last few years, however, detailed excavations at sites *BK* II, *SHK* II and *HWK* II have shown that there is a constant and well-marked break between the top of Bed I and the base of Bed II. It is incidentally on this clearly defined land surface that Chellean Stage I living sites are found.

There has also been found a great deal of new faunal evidence, and it is now clear that the fauna of Olduvai Bed I is the same as that of Omo, and that both are generally of the same age as that of Taungs. In other words, it is now necessary to regard Olduvai Bed I as representing the upper half of the Villafranchian and not the lower part of the Middle Pleistocene. So far as relative dating is concerned, it now seems clear that in the Far East the Djetis beds belong to the Middle, rather than to the Lower, Pleistocene, so that the new Olduvai skull would be older than the oldest *Pithecanthropus*.

In South Africa, the deposits at Taungs and Sterkfontein are now regarded as belonging to the upper part of the Lower Pleistocene ; they must therefore be regarded as generally contemporary with Olduvai Bed I. The Makapan beds are a little younger, in all probability, while Swartkrans is of Middle Pleistocene age, as are the upper beds at Sterkfontein which are now yielding stone tools.

With the Taungs child, therefore, and the *Australopithecus* fossils from the lower beds at Sterkfontein, the new find represents one of the earliest Hominidae, with the Olduvai skull as the oldest yet discovered maker of stone tools.

The following approximate measurements will indicate the size of the new specimen.

Length from inion to glabella	about 174 mm.
Greatest breadth at supra-mastoid torus	,, 138 mm.
Greatest breadth of brain case on squamosal element of the temporal bones	,, 118 mm.
Height (in Frankfurt plane) from basion to a point vertically above it in the sagittal plane	,, 98 mm.
External orbital angle width	,, 122 mm.
Inter-orbital width	,, 32·5 mm.
Post-orbital width	,, 88 mm.
Palate-length from front of incisors to a line joining back of third molars	,, 84 mm.
Palate-width at second molars	,, 82 mm.
Palate-width at third premolars	,, 62 mm.
Length of molar–premolar series	,, 72 mm.

Teeth measurements :

*M*3 : 21×16 mm. ; *M*2 : 21×17 mm. ; *M*1 : 18×15·5 mm. ; *PM*4 : 18×12 mm. ; *PM*3 : 17×11·5 mm. ; *C* : 9·5×9 mm. ; *C*2 : 7×7 mm. ; *C*1 (both damaged but about 10×8 mm.).

ASPIRIN AND ALGESIMETRY

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ASPIRIN relieves mild natural pain of various causes and locations. It is reasonable to expect, therefore, that it should raise the minimal noxious stimulus required for an experimental nociceptive response in animals or for experimental pain perception in man. This has been realized in several laboratories with satisfactory validity; but experiments have failed. Success and failure by respective procedures exist side-by-side in the same laboratory without explanation. We, like others, have repeatedly failed to demonstrate an effect of intraperitoneally administered aspirin on the threshold amount of mechanical pressure on a rat's tail required to induce squeaking[1]. We have succeeded, on the other hand, in showing an effect by the same route on the threshold intensity of radiant heat, applied to the back of guinea pigs, that is required to elicit a twitch of the skin muscles[2]. The success is often repeated[3]; and the dose of aspirin required is in appropriate relationship to doses of morphine or meperidine required in the same procedure—all high, relative to human doses.

Magnitude of Experimental Anti-nociceptive Effect

The greatest rise in nociceptive threshold caused by increasing intraperitoneal doses of aspirin in the guinea pigs is about 30 per cent[2,3]. Similarity of this magnitude to that originally reported by Wolff *et al.*[4] for the rise in radiant thermal threshold for pain perception in man is only coincidental. When the guinea pigs were given aspirin by stomach tube instead of intraperitoneally, even large, toxic doses caused no more than 10–15 per cent rise in threshold[5]. When Wolff's group adopted a less biasing experimental design with placebo control, a change bearing no relationship to the change in route of administration in guinea pigs, the ceiling of effect in man also became 10–15 per cent[6]. The factors responsible for the larger intraperitoneal effect in guinea pigs remain unknown.

A similar small effect of aspirin was observed in dogs by Andrews and Workman[7], using the same stimulus-response system afterwards used in the guinea pigs, and later by Richards[8]. Eagle and Carlson[9] tabulated a very small effect of aspirin on the rat's threshold to mechanical stimulation of the tail. Hart[10] and Bonnycastle *et al.*[11] obtained definite effects in rats with respective modifications of the D'Amour–Smith[12] procedure (tail flick in response to radiant heat). Gibson *et al.*[13] reported significant effects of the sodium salt of aspirin on the threshold strength of electrical stimulation of the rat's rectal mucosa required to induce squeaking. Deneau *et al.*[14], working with experimental deep pain of calf muscles in man, exhibited a clear-cut 10–15 per cent rise in the threshold stimulus associated with aspirin administration. Benjamin[15] showed that aspirin significantly delays the time when pain terminates work being done by the human forearm deprived of circulation, and presented results suggesting that more intensive work with less precise procedures would also show aspirin effects of statistical significance.

Thus, it seems inescapable that a small and subtle anti-nociceptive effect of aspirin can be demonstrated in the laboratory with brief noxious stimulation not obviously associated with inflammation, though the conditions required are poorly understood.

Site of Experimental Antinociceptive Effect

Cook and Bonnycastle[16] could find no effect of aspirin on spinal reflexes. They[11] found that relatively large amounts were required in the chronic spinal rat, as contrasted with the intact rat, to influence the tail-flick response to radiant thermal stimulation. It is inferred that at least a portion of the acute experimental anti-nociceptive action of aspirin, perhaps varying among successful experiments, occurs at neural mechanisms above the spinal level.

In this connexion, it is classical knowledge that nociceptive responses are potentially complete at the spinal level, especially in lower species, but that in the intact animal they are under constant control of a balance of active inhibitory and excitatory influences from high levels (for example, ref. 17). Unfortunately, since Irwin *et al.*[18] pointed out that the tail flick and the skin twitch are like other nociceptive responses in this respect, many writers have spoken of these two responses as "merely spinal reflexes"[18] even in the intact animal. Winter and Flataker[19] and Bonnycastle and Cook[11,16] have commented on this error.

Possible Role of Neurological Summation

During early work on twitch in the skin of the guinea pig, we found[2] that sensitivity of the threshold stimulus intensity to morphine varied significantly with the area and duration of the radiant heat stimulus. We selected as near optimal a large area (730 mm.^{2}) and an intermediate duration (4 sec.), determining threshold intensity as the dependent parameter. With this in mind, I suggested six years ago[20] that use of a pattern of stimulus characteristics emphasizing spatial or temporal neurological summation might in some way be a factor of success in demonstration of an anti-nociceptive effect by aspirin. The area of stimulation employed by Wolff's group[6] ordinarily was about 80–310 mm.^{2}, and presumably that of Andrews and Workman[7] was similar. Hart[10] prewarmed the rat's tail subliminally, thus providing a likelihood of temporal summation. Bonnycastle[11] pointed out the probable importance of his less intense and more prolonged stimulus. Deneau's[14] pressure-cuff affected a large muscle mass. Gibson's[13] rectal electrode was relatively large. Benjamin's[15] uncirculated forearm was a considerable mass of tissue.

This will recall the well-known opinion of Wolff's group[6], based on work with liminal 'pricking pain', that pain sensation is neurologically unique in lacking the property of spatial summation. Rather, these workers' results would seem to indicate a very pronounced central occlusion of a smaller liminal field by a larger one[2], reflecting at once the poor local sign of pain and a very efficient central convergence of excitation. Even so, spatial facilitation manifests itself near the limen, either for the subjective sensation[21] or for the nociceptive response[2].

Insufficiency of Central Anti-nociceptive Action Alone

However real, a central neural action so small and subtle as that of aspirin seems inadequate by itself to account for the efficiency with which the drug relieves natural pain. Goetzl[22] came to this conclusion on viewing his own negative experimental results with aspirin together with older work. Now there are more positive kinds of evidence.

During the past two decades many compounds of miscellaneous structure have been reported in the pharmacological literature to possess experimental anti-nociceptive potencies in animals more or less superior to that of aspirin but inferior to that of codeine. Many of these have been tested clinically; but none has been generally accepted. Two such compounds with which we have worked were more powerful anti-nociceptives in guinea pigs than aspirin, and, by contrast with aspirin, were significantly though not strongly anti-nociceptive in rat tail-pinching experiments (α-piperidyl-3,4-dichlorophenylacetic acid, monohydrochloride, and 1-(1-piperidyl)-1-cyclohexanecarboxamide, monohydrochloride; synthesized by E. M. Jones and P. J. Ehrlich (1950–51); evaluated for anti-nociceptive action by J. Wax, J. Lyon, S. Kaprielian, V. Burr, M. Been and C. V. Winder (1950–54).) Yet, in natural human pain, both were significantly ($P = 0.05$) inferior to aspirin, if, indeed, effective at all[23].

The history of salicylamide is instructive. The anti-nociceptive action of this old compound is sufficiently greater than that of aspirin to be demonstrable in many laboratories. Yet the drug's analgetic efficacy, long in doubt before the recent attention it has enjoyed, is now again in serious doubt[24]. Derivatives of salicylamide even more potent as anti-nociceptives in animals also have failed as yet of clinical acceptance, at least one being significantly[25] and another fairly probably[26] less effective than aspirin in natural pain.

It is therefore now reasonably clear that a degree of experimental central anti-nociceptive action somewhat greater than that of aspirin is not, by itself, predictive of clinical analgesia. It is conceivable, though unsupported, that the quality of central action by aspirin differs from that of many other kinds of agents in such manner that, even though small, it could account for relief of natural pain.

One consequence of this working attitude is that many of us need no longer be so concerned with boxfuls of experimental compounds having no more anti-nociceptive action than, say, salicylamide, excepting those for which evidence can be found of some adjunctive action that could potentiate a small anti-nociceptive effect in the relief of pain.

Adjunctive Anti-preinflammatory Action

Returning to aspirin in search of some adjunctive property, one sees most prominently the drug's well-established anti-rheumatic effect, a fairly specific anti-inflammatory action in the acute phases of rheumatic diseases. It could be a suppression of some rather early process—a preinflammatory process—in the course of reaction by tissue to injury. The same process could lead both to stimulation of pain endings and, eventually, to frank inflammation. It could be a process more or less common to early tissue injury associated with various kinds of natural pain. It would probably take longer to develop than the duration of most experimental noxious stimuli.

The hypothesis that a peripheral anti-preinflammatory property is essential in the relief of natural pain by aspirin gains stature on again considering salicylamide. Doubt concerning the analgetic efficacy of this agent, in spite of supra-aspirin anti-nociceptive potency, parallels doubt concerning its anti-rheumatic efficacy[24b]. A complementary test of the hypothesis is provided by aminopyrine. With a similar order of anti-nociceptive potency, the unquestioned analgetic efficacy of this drug parallels its unquestioned anti-rheumatic efficacy.

Harris proposed several years ago[27] that the pain-relieving effect of aspirin could be explained entirely in terms of a peripheral anti-inflammatory action. The present hypothesis differs in considering, rather, an anti-preinflammatory action as an adjunct which, as may become apparent later on, is probably not entirely sufficient by itself.

Adjunctive Actions of Other Kinds

It is likely that other poperties of aspirin sometimes contribute to its ability to relieve mild pain. In pre-equilibrium phases of certain febrile states the antipyretic effect may relieve muscle soreness in part via reduction of muscle tonus.

The hypothetical necessity of an anti-preinflammatory action in aspirin or aminopyrine for significant relief of natural pain would, correlatively, require that another kind(s) of adjunctive action be identified in the acetanilid group. Neither acetanilid nor acetophenetidin is clearly antirheumatic in ordinary clinical doses[28], nor is N-acetyl-*p*-aminophenol known to be, yet all are considered able to relieve mild pain[24a,28]. However, all have the underlying anti-nociceptive action. Acetanilid and acetophenetidin are, perhaps, more potent than aspirin in this respect[22]. N-acetyl-*p*-aminophenol, the main metabolic intermediary of both[29] and perhaps substantially responsible for their anti-nociceptive action[30], is about equally potent[31]. Moreover, all are antipyretic[28,31] and, in addition, seem to possess a pattern of sedative and relaxing properties[4,28] that could be importantly adjunctive to the anti-nociceptive action[4].

Insufficiency of Adjunctive Properties Alone

Analgetic efficacy in the acetanilid group thus suggests an underlying importance in a mild analgetic agent of anti-nociceptive action, small and subtle though it may be. Mere absence of pyrexic malaise and muscle tension, or of anxiety, or presence of mild sedation, is not *per se* generally analgetic.

The case of phenylbutazone indicates that anti-rheumatic potency alone is insufficient for prediction of general analgetic efficacy. This drug is now well known to be the most potent anti-rheumatic agent outside the cortisone group, yet there seems to be no firm evidence for utility in relieving pain except in grossly inflammatory diseases. Correspondingly, though large intravenous doses were anti-nociceptive[32], we have been unable to detect such action at sublethal intraperitoneal doses in guinea pigs, or at a fourth the LD_{50} of the drug intraperitoneally in rats[33]. Fewer rheumatologists are now referring to phenylbutazone's 'analgetic' action, and more to its anti-inflammatory action.

Lack of known usefulness of cortisone-like agents as general-purpose analgetics may not be pertinent These glucocorticoids possess a different kind of peripheral anti-inflammatory action[34], perhaps not impinging so specifically on particularly early reactions to tissue injury that lead directly to stimulation of pain receptors

Thus, it has been our working hypothesis for the past few years that the small, central, anti-nociceptive action of aspirin or aminopyrine, though necessary, is not sufficient by itself for mild analgesia , but is effectively potentiated (?) by a peripheral anti-preinflammatory action related to non-steroidal anti-rheumatic action which, however, is also insufficient alone

One interesting implication is an explanation of the old and growing clinical popularity of mixtures of codeine with aspirin, or of aspirin and acetophenetidin The anti-nociceptive effects of the two or three agents would be additive The more general sedative effects of codeine and acetophenetidin would, perhaps, add The combined anti-nociceptive effect would amplify the peripheral anti-preinflammatory effect of the aspirin and the sedative effect of the codeine and acetophenetidin The end clinical action of the combination of drugs might be somewhere between addition and multiplication of the individual drug effects

A Laboratory Model of Pre-inflammation

For several years we have been studying the influence of drugs and chemicals on development of erythema on albino guinea pigs following exposure to ultra-violet energy[34] , a procedure first employed by Wilhelmi[32,35] This experience has strongly influenced development of the foregoing hypothesis

In a standardized procedure wherein the erythema is developed 2 hr after exposure, divided-dose pretreatment with a typical non-steroidal anti-rheumatic agent delays the appearance of the erythema in a proportion of animals depending on dosage Significantly effective divided doses of various agents in the experiment closely approach daily anti-rheumatic doses in the clinic, on a body-weight basis

Aspirin and aminopyrine are effective in this test they are anti-rheumatic, anti-nociceptive and analgetic Salicylamide is not effective , it is doubtful as an anti-rheumatic, and, in spite of easily shown anti-nociceptive action, is doubtful as an analgetic The two supra-aspirin experimental anti-nociceptives mentioned earlier that were found ineffective as clinical analgetics[23] were not effective in this test[36] Phenylbutazone is most potently effective , it is most potently anti-rheumatic, yet not clearly anti-nociceptive and not, apparently, generally analgetic The acetanilid group presents the same problem discussed earlier These agents are not effective in the ultra-violet erythema test at dose-levels that would be tolerated , they are not usefully anti-rheumatic , but, nevertheless, their anti-nociceptive action apparently provides an underlying basis for mild analgesia, perhaps essentially aided by a more general action on the central nervous system

The ultra-violet tissue injury sets off a pre-inflammatory phenomenon amenable to influence by non-steroidal anti-rheumatic agents Presumably it is related to a pre-inflammatory phenomenon in various painful tissue states which these same agents influence when, provided they also have some central anti-nociceptive effect, they relieve pain

Cortisone-like agents do not influence the erythema[34c], have different kinds of effects on inflammatory processes, and are neither anti-nociceptive[19] nor known to be generally useful as analgetics The more potent analgetic agents from codeine upward do not delay the erythema and have no specific anti-rheumatic effect Their pain-relieving actions are central and are associated with sufficiently robust experimental anti-nociceptive effects so that there is no great difficulty in comparing them in the laboratory in terms of acute, non-inflammatory pain

One can only speculate on the nature of pre-inflammatory processes induced by noxious tissue states, leading to stimulation of pain endings and eventually to frank inflammation, and susceptible to agents like aspirin It is conceivable that some clarification might come from work now being done in several laboratories on activation of proteases and/or globulins, formation of kinins, release of potassium, etc [37]

More Complete Laboratory Models of Natural Pain

If the ordinary experimental noxious stimulus is, perhaps, too brief to allow development of the pre-inflammatory state upon which aspirin seems to have an essential component of its action, then it is natural to consider having this state pre-established as a part of the eventual total stimulus We were therefore gratified to note a description by Randall and Selitto[38] of a laboratory model of inflammatory pain—measured pressure applied to the inflamed and œdematous foot of the rat One is reminded of Schumacher's[39] earlier work on the effect of aspirin on experimental pain thresholds of inflamed human skin

Using the inflamed foot, Randall and Selitto found sodium salicylate, acetophenetidin, N-acetyl-*p*-aminophenol, and phenylbutazone effective in raising the threshold pressure required for a nociceptive response It is somewhat discouraging that aminopyrine was not significantly more effective than sodium salicylate —a deviation from clinical experience It is interesting and more understandable that acetophenetidin and N-acetyl-*p*-aminophenol were only a half to a quarter as potent as sodium salicylate, even though they were more potent central anti-nociceptives as measured with the normal, uninflamed foot This agrees with the absence either of anti-rheumatic and anti-erythemic (ultra-violet) effects of these two agents at tolerated dosage, or of any obvious means for reflexion of their adjunctive sedative properties in the results Also, it is gratifying that phenylbutazone was only slightly more potent than sodium salicylate, and would thus be predicted to have general analgetic utility, if any, only at doses much larger than can safely be employed clinically for the anti-rheumatic effect This agrees with the present lack of clinical evidence of general utility as an analgetic, and with absence of clear anti-nociceptive action at subtoxic doses (*supra*)

Randall and Selitto[38] suggest a liability in their model that we believe may be inherent in any involving œdema[34a]—a liability to indirect effects from vascular disturbances caused by the agent on test It will be interesting to study the properties of a model in guinea pigs combining the relatively non-œdematous[34c] ultra-violet inflammation and the acute, wide-area radiant heat stimulus[2,3]

Recently, mice injected intraperitoneally with appropriate amounts of phenylquinone[40] or acetic acid[41] have been observed to 'writhe'[40] or 'stretch'[41] repeatedly and for long periods The phenomenon is suppressed by suitable doses of aspirin or aminopyrine, as well as by the more potent central analgetics The stimulus, presumably noxious, differs in two important respects from those considered hereto First, it is applied to a larger tissue surface, potentially bringing into play a much broader pattern of neurological convergence Secondly, it is present for a longer time, at once providing possibilities of temporal neurological summation and of maturation of preinflammatory processes In terms of the present thesis, any or all of these factors would improve sensitivity to agents like aspirin or aminopyrine

High doses of acetophenetidin required to suppress writhing in one laboratory[40], and of salicylamide in another[41], recall again the poor activity of these agents as anti-rheumatics or anti-erythemics (ultra-violet) and suggest that the writhing stimulus leans to some extent on a pre-inflammatory component Discrepancy between the two laboratories in effectiveness of sodium salicylate is puzzling Suppression of the writhing by a variety of chemicals and drugs[41,42] renders the phenomenon rather enigmatic at present

It may be that, with increasing attention to matters like extensity, duration and quality of stimulus, as well as to higher-level neurological conditioning[43], research workers will gradually resolve the differences between experimental and natural pain so long and vigorously emphasized by Beecher[44]

[1] Winder, C V , Wax, J , Burr, V , and Been, M (unpublished experiments, 1952–1954, by a slight modification (Winder, C V , Jones, E M , Weston, J K , and Gajewski, J , *Arch int Pharmacodyn* , in the press) of an original procedure (Green, A F , Young, P A , and Godfrey, E I , *Brit J Pharmacol* , **6**, 572, 1951))

[2] Winder, C V , Pfeiffer, C C , and Maison, G L , *Arch int Pharmacodyn* , **72**, 329 (1946)

[3] *Ibid* , **74**, 176, 219 (1947)

[4] Wolff, H G , Hardy, J D , and Goodell, H , *J Clin Invest* , **20**, 63 (1941)

[5] Wax, J , Kaprielian, S , Asher, E , and Winder, C V (unpublished experiments, 1950–1951)

[6] Hardy, J D , Wolff, H G , and Goodell, H , "Pain Sensations and Reactions" (Williams and Wilkins, Baltimore, 1952)

[7] Andrews, H L , and Workman, W , *J Pharmacol* , **73**, 99 (1941)

[8] Richards, R K Paper presented at the twelfth meeting of the Committee on Drug Addiction and Narcotics, N R C –N A S , held at Boston, Mass , Nov 6–7, 1953

[9] Eagle, E , and Carlson, A J , *J Pharmacol* , **99**, 450 (1950)

[10] Hart, E R , *ibid* , **89**, 205 (1947)

[11] Bonnycastle, D D , Cook, L , and Ipsen, J , *Acta pharm tox* , *Kph* , **9**, 332 (1953)

[13] D'Amour, F E , and Smith, D L , *J Pharmacol* , **72**, 74 (1941)

[13] Gibson, R D , Miya, T S , and Edwards, L D , *J Amer Pharm Ass* , *Sci Ed* , **44**, 605 (1955)

[14] Deneau, G A , Waud, R A , and Gowdey, C W , *Can J Med Sci* , **31**, 387 (1953)

[15] Benjamin, F B , *Science*, **128**, 303 (1958)

[16] Cook, L , and Bonnycastle, D D , *J Pharmacol* , **109**, 35 (1953)

[17] Melzack, R , Stotler, W A , and Livingston, W K , *J Neurophysiol* , **21**, 353 (1958)

[18] Irwin, S Houde, R W , Bennett, D R , Hendershot, L C , and Seevers, M H , *J Pharmacol* , **101**, 132 (1951)

[19] Winter, C A , and Flataker, L , *ibid* , **103**, 93 (1951)

[20] During the meeting referred to in ref 8

[21] Hall, K R L , *Nature*, **182**, 307 (1958)

[22] Goetzl, F R , *Permanente Found Med Bull* , **4**, 49 (1946)

[23] Houde, R W , and Wallenstein, S L (personal communication, 1956) , Carr, E A , jun (personal communication, 1957)

[24] (*a*) Wallenstein, S L , and Houde, R W , *Fed Proc* , **13**, 414 (1954) , (*b*) Batterman, R C , and Grossman, A J , *J Amer Med Assoc* , **159**, 1619 (1955) , (*c*) Currier, R D , and Westerberg, M R , *Univ Mich Med Bull* , **24**, 415 (1958)

[25] Carlsson, A , and Magnusson, T , *Acta pharm tox* , *Kph* , **11**, 248 (1955)

[26] Lasagna, L Report to the nineteenth meeting of the Committee on Drug Addiction and Narcotics, N R C –N A S , held at Bethesda, Md , March 29, 1958

[27] Harris, S C Paper presented at a meeting of the Pain Group held in conjunction with the meeting of the Federation of American Societies for Experimental Biology, at Atlantic City, April 13, 1954

[28] (*a*) Goodman, L S , and Gilman, A , "The Pharmacological Basis of Therapeutics", 2nd Ed (Macmillan, New York, 1955), pp 311–316 , (*b*) Smith, P K , "Acetophenetidin, a Critical Bibliographic Review" (Interscience Publishers, New York, 1958)

[29] Brodie, B B , and Axelrod, J , *J Pharmacol* , **94**, 22 (1948) , **97**, 58 (1949)

[30] Flinn, F B , and Brodie, B B , *ibid* , **94**, 76 (1948)

[31] Boreus, L -O ,, and Sandberg, F , *Acta physiol scand* , **28**, 261 (1953)

[32] Wilhelmi, G , *Schweiz med Wschr* , **79**, 577 (1949)

[33] Montibeller, W , Wax, J , Been, M , Burr, V , and Winder, C V (unpublished experiments, 1953–1954)

[34] (*a*) Winder, C V , Wax, J , and Been, M , *Arch int Pharmacodyn* , **112**, 174 (1957) , (*b*) Winder, C V , Sarber, R W , Hemans, M , Wax, J , and Bratton, A C , jun , *ibid* , **112**, 212 (1957) , (*c*) Winder, C V , Wax, J , Burr, V , Been, M , and Rosiere, C E , *ibid* , **116**, 261 (1958)

[35] (*a*) Wilhelmi, G , *Schweiz med Wschr* , **80**, 936 (1950) , (*b*) Wilhelmi, G , and Domenjoz , R , *Arch int Pharmacodyn* , **85**, 129 (1951)

[36] Winder, C V , Wax, J , and Burr, V (unpublished experiments, 1954)

[37] (*a*) Ungar, G , *Lancet*, **263**, 742 (1952) , (*b*) Armstrong, D , Jepson, J B , Keele, C A , and Stewart, J W , *J Physiol* , **135**, 350 (1957) , (*c*) Mill, P J , Elder, J M , Miles, A A , and Wilhelm, D L , *Brit J Exp Path* , **39**, 343 (1958) , (*d*) Margolis, J , *Nature*, **181**, 635 (1958) , (*e*) Spector, W G , and Willoughby, D A , *J Path Bact* , **77**, 1 (1959) , (*f*) Chapman, L F , Goodell, H , and Wolff, H G , *Fed Proc* , **18**, 25 (1959) , (*g*) Benjamin, F B , *ibid* , **18**, 10 (1959) , (*h*) Ungar, G , and Chapman, L F , papers presented at a meeting of the Pain Group held in conjunction with the meeting of the Federation of American Societies for Experimental Biology, at Atlantic City, N J , April 14, 1959

[38] Randall, L O , and Selitto, J J , *Arch int Pharmacodyn* , **111**, 409 (1957) , *J Amer Pharm Assoc* , *Sci Ed* , **47**, 313 (1958)

[39] Schumacher, G A , *Res Publ Assoc Nerv Ment Dis* , **23**, 166 (1943)

[40] Siegmund, E , Cadmus, R , and Lu, G , *Proc Soc Exp Biol* , **95**, 729 (1957)

[41] Koster, R , Anderson, M , and de Beer, E J , *Fed Proc* , **18**, 412 (1959)

[42] Shanaman, J E , Emele, J F , and Warren, M R , *ibid* , **18**, 443 (1959)

[43] Hill, H E , Pescor, F T , Belleville, R E , and Wikler, A , *J Pharmacol* , **120**, 388 (1957)

[44] Beecher, H K , *Pharmacol Rev* , **9**, 59 (1957)

CHANCE AND PROBABILITY

If the fundamental concepts of mathematical probability and their role in statistical theory are still subject to sharp controversy after three centuries of discussion by the acutest minds, we can scarcely expect that the concepts of psychological probability, born within the past decade, should already have found general acceptance It is not indeed clear to everyone where mathematical probability ends and where psychological probability begins, if it is justifiable to separate them at all The papers presented at a session of Section J (Psychology) during the York meeting of the British Association at least shared the view that the study of psychological probability unquestionably offers important opportunities for research into hitherto unexplored realms of mind and behaviour The three papers presented were "Wishful Seeing in a Gambling Situation", jointly by Dr John Beloff and Mr Kenneth Warwick (Queen's University of Belfast), and read by the former , "Chance and Uncertainty", by Dr W Mays (University of Manchester), read in his absence by Dr D McMahon , and "The Psychology of Luck", by Prof John Cohen (University of Manchester)

The paper by Dr Beloff and Mr Warwick was devoted to an experimental study of 'perceptual autism', an expression coined by Prof Gardner Murphy in 1947 to refer to those subjectively distorted changes in perception which have the effect of gratifying the observer's needs—in other words, wishful seeing. The context of the experiments was a type of gambling situation. As a point of departure they took various investigations by Murphy and his colleagues designed to establish the autistic phenomenon and they discussed the criticism that the observations could be explained in terms of the familiar notions of 'expectancy' or, alternatively, in terms of 'response availability' without postulating a special autistic mechanism. Thus if a hungry man, on being shown an inedible object, says that it is something edible, it does not follow that he says so because he sees it as such but merely because he would naturally be thinking of things to eat. Dr. Beloff's experiments were designed to rule out these alternative explanations.

Three distinct experiments were conducted. In the first the subject had to guess which of four possible visual stimuli would appear in a brief tachistoscopic exposure. Before each exposure the subject was told that a square (with a cross inside) would be shown with one of the sides missing, and he had to guess which one it would be. He was given money with which to bet on his guess. On the autistic hypothesis the guesses should tally with the bets on a statistically significant number of occasions.

In this first experiment there were two series of presentations, one random and one biased. In the random series, the subject presumably had no 'reason' to believe that a particular card was more likely to appear at a given trial, whereas in the biased series it was experimentally possible to distinguish between what the subject 'expected' and what he 'wanted' to appear. There was a significant autistic effect, in spite of marked individual differences in patterns of response. This led Dr. Beloff to suggest that autism is a feature of personality and, in this sense, akin to optimism.

In order to meet the possible objection that this outcome was due to 'response availability', the second experiment introduced a new series which required the subject to bet on the card which he expected *not* to appear, and to forfeit his bet if it did. The reward series again revealed an autistic effect but not the penalty series, the bet-guess correspondence being at chance-level.

In the third experiment a further attempt was made to ensure that the hypothesis of 'expectancy' could be eliminated by depriving the subject of the power of deciding which of the four cards was to be rewarded. The subject now won his bet if the stimulus corresponded to a particular counter drawn at random in advance of the exposure. This experiment seemed to show clearly that "once desire is divorced from expectancy by introducing an *arbitrary* system of rewards and penalties, the autistic effect no longer operates". Without denying that emotions may influence perception autistically, Dr. Beloff concluded that there is no need to assume a special central determinant, as proposed by Prof. Murphy.

Dr. Mays's paper discussed certain logical and psychological issues arising in the study of probability in general. He began by referring to Venn's views expressed in his "Logic of Chance" (1876) and passed on to a more detailed criticism of Prof. S. E. Toulmin's contribution to an Aristotelian Society symposium on probability in 1950. As to Prof. Toulmin's question of the meaning of 'probability', Dr. Mays stated: "the answer is probably very little, since it refers to a generalized situation, not always specifiable by concrete operations". In his view, Prof. Toulmin under-estimated the extent to which adult thinking is permeated by technical ideas deriving from games of chance.

Dr. Mays stated that psychologists had studied the pragmatic understanding of probability from two points of view: that of methodology and that of concept formation. He thought that the initial impulse to study subjective probability had come from experiments on extra-sensory perception, and suggested that descriptions of the way people behave in experimental probability situations ought not to be taken as a guide to rational behaviour, that is, as ethical norms, which subjective probability, in the sense used by Ramsey and Savage, is evidently meant to be.

Much of Dr. Mays's paper took the form of a critical résumé of the views of certain psychologists, notably Goodfellow and Piaget. The main feature of Piaget's work, he declared, is to take "the abstract calculus of probabilities as an objective standard of mature behaviour, and deviations from it (the so-called illusions) as a mark of immaturity". The concept of 'chance', according to Piaget, is not an intellectual intuition, but has to be learnt; since the child endeavours to find a causal factor in everything he observes, he cannot apply the notion of equi-possibility of probability situations. The child's notion of probability, in Piaget's view, only appears when he has built up a system of logical operations enabling him to contemplate possibilities (in terms of combinations and permutations) beyond what actually happens.

Dr. Mays believes that there is little to be said in favour of the belief in a special type of subjective probability postulated to cover what he described as "really an amalgam of emotional attitudes, intellectual systems, etc.", an approach which reminded him "of the instinct psychologists and the Aristotelians who postulated a new type of instinct for every form of behaviour".

Prof. Cohen placed the study of luck in the context of psychological probability. The belief in luck, he suggested, originated in the attempt to master life's uncertainties. As societies become more civilized their uncertainties do not diminish. Hence the idea of luck survives with full vitality. The examination of luck formed part of a systematic series of studies, initiated at Manchester in 1952, into those forms of thought and behaviour which characterize states of uncertainty: choice, estimation, prediction, inference, risk-taking, and decision-making generally; and the method of investigation was at once experimental and developmental. He ventured to make two inferences from his earlier inquiries which had a bearing on the present one. First, the idea of 'randomness' is alien to the human mind, which is essentially pattern-seeking or, in more general terms, engaged in an implicit or explicit search for meaning. Secondly, there is evidence that our minds act as unwitting 'computers' and, under certain conditions, an analogy can be drawn between quasi-additive and quasi-multiplicative operations in psychological probability and the fundamental properties of mathematical probability.

Prof. Cohen then considered the meaning of 'luck' in terms of observed usage, principally in the twofold sense of 'unearned advantage' and 'fortuitous intervention'. He illustrated the survival of beliefs in luck by reference to the fact (as he had found) that young and old alike still have their lucky colours, days and numbers Moreover, people are believed to have stores of luck which can be depleted and replenished, and there is evidence that women felt themselves to be luckier than men

Prof Cohen was mainly concerned to describe experimental demonstrations of the effect of a belief in luck on expected performance and achievement Thus, a subject could estimate realistically his likely performance at any given task This estimate could then be compared with other estimates of his likely performance if he thought he would be (*a*) lucky, (*b*) very lucky, (*c*) unlucky, (*d*) very unlucky From a variety of experiments of this kind it seemed that, within a given range of tasks, to be lucky signified an expected improvement in performance of some 10 per cent, and to be very lucky, of 20 per cent Unluck meant an expected deterioration of 30 per cent and very bad luck anything up to 80 per cent

An allied effect of the belief in luck could be measured in terms of the proportion of attempts in which the subject expected to succeed at particular tasks varying in level of difficulty Here, too, the pattern of realistic estimates could be compared with the pattern of estimates of success with varying degrees of expected luck and unluck Psychological probabilities derived in this fashion revealed that when tasks are of comparable subjective difficulty the patterns of estimates of expected performance bear a striking mutual resemblance Furthermore, a pessimistic under-estimation of one's capacity appeared when the task seemed subjectively easy and an optimistic over-estimation when it seemed hard A generalization of particular interest could be embodied in the formula

$$\psi_{l}^{p} \quad + \quad \psi_{\bar{l}}^{1-p}=1$$

where ψ represents the psychological probability, p the *a priori* probability of success, and l (and $\bar{l}$) the degree of luck (or unluck) to which the original estimate relates What is conveyed by this formula is the empirical observation, based on many experiments, of the quasi-additive character of psychological probabilities Suppose, for example, that the *a priori* probability of a subject's success at a task is 0 1, and that his corresponding psychological probability, if he thinks he will be very 'lucky', is 0 6 , then when the *a priori* value of success at a similar task is 0 9, his psychological probability of success if he thinks he will be very 'unlucky' turns out to be approximately 0 4 The additive property appears when the values of ψ are derived from estimates made after as well as in advance of performance

A different analysis was employed by Prof Cohen to measure the frequency with which we think good or ill fortune will befall us In his experiments, the estimate of performance which is regarded as most realistic is expected by the subject to occur on some 52 per cent of the occasions, the lucky (or unlucky) outcome on some 17 per cent and the very lucky (or very unlucky) outcome on some 7 per cent These experiments, Prof Cohen believes, shed light on the basis of our aspirations For in everyday life we are often governed by unrealistic considerations, and what we are, in fact, prepared to undertake may depend basically on what we imagine we should achieve if we were lucky or unlucky The range and pattern of psychological probabilities might justify the assumption of a sort of inner 'standard deviation' of judgment

Prof Cohen also spoke at some length of social repercussions of a belief in luck, particularly as a stabilizer in allaying socio-economic envy, and in discouraging initiative , and he referred to the 'magical' significance of the practice of disparagement, both of self and of others In conclusion, he drew a parallel between individual and cultural psychological probability, in that the phenomenon of pseudo-subjective dependence (or the Monte Carlo fallacy) has its analogue in the cyclic, as contrasted with the linear, conception of time and history which characterizes traditional and archaic cultures

COAST EROSION AND ACCRETION

IT is almost true to say that , despite the full and interesting reports of the Royal Commission on Coast Erosion (1907–11), little effective action on the coasts of Britain was taken until the severe flooding of 1953 occurred A Departmental Committee was then appointed under the chairmanship of the late Lord Waverley, and in 1954 made two relatively short reports containing a number of recommendations Three of them are particularly relevant to this article No 10 reads "that steps should be taken to ensure proper co-ordination of researches Recourse might well be had for this purpose to the constitution of two consultative and advisory standing committees There should be close co-operation on research matters between British and Dutch scientists, engineers and Governments" Recommendations 2 and 3 emphasized the necessity of research into "the behaviour and suitability of vegetation for use on sand, shingle and other material adjacent to the sea", and "the urgency of research into the movements of beach material, off-shore banks and related coastal problems" Thus the discussion organized by Sections E (Geography) and K (Botany) at the recent British Association meeting at York was particularly relevant

The two standing committees referred to have been formed, and the one devoted to sea defences is that most concerned with this article The other is primarily concerned with tidal and oceanographical matters The sea defence committee, under the chairmanship of Mr E A G Johnson, of the Ministry of Agriculture, Fisheries and Food, has already made three reports to the Ministers concerned (Agriculture, Fisheries and Food, Housing and Local Government, and the Secretary of State for Scotland) The committee is very alive to the physical and ecological problems affecting our coast, and Mr G Cole, who acts as secretary, was one of the speakers at York It is the first time in Britain that such complete co-ordination on coastal problems has been attained Mainly through the personnel of the committee very close contact is maintained with the Hydraulics Research Board, the Nature Conservancy, the Building Research Station (in connexion with sea-wall and sea-bank construction), and the universities Since, too, radioactive and other tracers are becoming more and more significant in coastal work, there is also a close link with Harwell

In practice the erection of sea defences of one kind or another is the work of engineers, either consultants or those connected with river boards, or local or national authorities But all who are interested in the coast are concerned among other matters with the source, supply and maintenance of beach material, and with the holding of dunes and the formation of marsh Experience has shown all too often that indiscriminate building of groynes and walls may have very serious effects in other places Since the natural protection of much of our coast is a good beach, it is all important to study how it is to be maintained Careful surveys made by members of the Department of Geography at Nottingham showed that it took 5 or 6 years before the Lincolnshire beaches were restored fully to the level they reached before the 1953 flood scoured them almost completely In many cases it is possible to assume with a fair degree of certainty that a beach is fed by lateral transport If this is interfered with at some locality sites to leeward are bound to suffer But there are places, for example Scolt Head Island, where it is not unreasonable to assume that new material comes more from offshore than alongshore This matter of offshore supply is one that is frequently debated, and one that perhaps can be finally settled only by tracer or aqualung methods Already some useful results based on observations by divers have been obtained at Scripps Institute of Oceanography and a beginning has been made in Britain by the physiographic unit of the Nature Conservancy Careful observations by trained men in water down to a depth of perhaps 100 feet may help very greatly in many shore problems These more recent methods of approaching the question of supplies of beach material do not in any way mean that the type of studies already in use should be discontinued Far from it, they should be pursued vigorously, and to 'know' a beach implies a long study. It may sometimes be necessary in building defences to act hurriedly, and it may happen that the result is successful In general, however, the study of a beach over a period including all types of weather likely to act upon it is desirable Moreover, it is also valuable to be able to make comparative studies Conditions are never exactly the same in any two places, but a great deal can be learned by studying comparable localities on different parts of the coast

The four papers that followed the introductory remarks dealt mainly with specific problems and places Dr M C Pearson, of the University of Nottingham, discussed the biology of the sea buckthorn (*Hippophae rhamnoides*) This shrub enters the succession of sand-binding plants after the marram grass stage It is found in Britain only on coastal sand dunes, and is common on certain parts of the east coast Dr Pearson's studies have been made at Gibraltar Point, a nature reserve at the north-eastern corner of the Wash It has been found that most of the plants originate from underground stems and but very few from seed This is partly explained as a result of the predation of seeds by birds and small mammals The shrub carries big spines, and so may form a deterrent to grazing animals and even to picnickers In that sense it may have value in keeping certain parts of the dunes free from erosion caused by trampling In any event it is of value in fixing the dunes, and it is used partly in that way in Holland Further research work on this interesting species is planned

Mr Cole's paper was concerned with the gathering and stabilizing of sands, silts and clays by vegetation He pointed out that only along a relatively short distance (60–70 miles) of the total length of the coast of England and Wales do dunes form the sole or partial defence, and salt marshes cover even less distance He discussed several interesting examples of the artificial accumulation of sand dunes around brushwood or other type of fencing or obstacle, and also the effect of various grasses in their relation to dune and marsh growth The remarkable growing power of marram was pointed out, but he stressed the view that its ramifying and long roots may have little effect in binding the sand The building of a new dune by British Railways at Dawlish Warren, and the planting on it of tree lupin (*Lupinus arboreus*) following the marram, was taken as a good example of the artificial production and maintenance of sand dunes

In the development of marshes the planting of *Spartina* was mentioned This grass has spread rapidly on the south coast and is now invading, sometimes all too successfully, the east coast Dr D Ranwell, of the Nature Conservancy, has recently been engaged upon methods for its eradication It will be noted that *Spartina* in this paragraph is not followed by any specific name Dr C E Hubbard, of Kew, has shown that the grass which has grown so extensively in Southampton Water and is regularly used for planting and reclamation elsewhere is not *S townsendii* but rather a chance offspring of that plant, and that so far it has not been given a specific name

Mr Cole very rightly made the point that it is wrong to rely too much on one or two species If for some reason disease developed in marram or *Spartina* grave difficulties might arise There should be experimentation with vegetation and, in certain carefully controlled circumstances, we should introduce foreign species The idea of a 'coastal garden' in which such experiments could be made has already been adumbrated

Mr C Kidson was also concerned with this same point He has studied certain parts of the coast in great detail, and as physiographer of the Nature Conservancy he has been able to make comparisons with many other parts His studies on the Somerset coast have shown the value of *Spartina* in accumulating sand and silt, and it is estimated that in part of Bridgwater Bay the level of the foreshore has been raised 5–7 feet since 1928 But here again all is not as it should be *Spartina* may act locally almost like a groyne, and it is able to hold up the longshore transport of shingle In one place 60 feet of spartinetum was overridden by shingle in one year The shingle beach behind, cut off from its supply, was combed down in big storms and became lower and so less of a protection to the land behind Mr Kidson also directed attention to the interesting work that is now being carried out along the west coast of Denmark There the foreshore has been built up by *Salicornia* spp and *Puccinellia maritima* Their spread has been much aided by the building of low brushwood dams and shallow drainage channels He also directed attention to the possibility of *Suaeda fructicosa* holding mobile shingle It is a habit of this shrub to grow at the head of marshes and at the foot of shingle ridges Prof Oliver, in his studies of Blakeney Point, directed attention to it many years ago It is doubtful if the plant can be a real deterrent to shingle movement

The remaining paper, although given earlier in the sequence, dealt with the coast of part of Lancashire

Mr Gresswell, of the University of Liverpool, has made several extensive studies of this It is put last here because it was rather less concerned with vegetation than were the others Nevertheless, South Lancashire is faced with a dune coast, and one made use of perhaps more than any other dune area in these islands The speaker discussed the erosion at Formby and the accretion at Southport This coast illustrates extremely well how difficult it is to estimate what will happen in the future Formby and district have been suffering loss for some 50 years , before then the same area was gaining at about the rate it is now losing Inland of Southport and Formby is a belt of rich agricultural land below the level of high tides, and only protected by the dune belt The dunes have long been controlled, and extensive pine forests cover part of them But these will not stop erosion Extensive sea walls may do so, and in a limited way so also may bulk accumulation—the artificial gathering of sand by brushwood groynes and careful planting This will increase the amount to be eroded by the waves , it cannot stop the erosion It may also be possible to raise the height of the beach by building groynes and stopping the sand which moves both to north and to south away from Formby But then how will this affect Southport ? The lesson has been learnt a little farther north · the protection of Blackpool has starved the beaches at Fleetwood and caused severe damage there

Change is constant along the coast , it is most noticeable in those parts faced by soft cliffs or by low-lying ground fringed by dunes and marshes It is much slower, and perhaps not measurable in a life-time, on a coast faced by cliffs of resistant rock Coastal studies are not only of significance to all dwellers along the sea and owners of land adjacent to it, but they are also of particular interest to workers in many branches of science, archæology and history. Coastal defence, in the long run, must benefit by the more leisurely rate at which certain experimental work has to be undertaken Botanists, physiographers and others, of several of our universities, are now much concerned with coastal research, and their findings are appearing with some regularity. The more we know of any particular stretch, the more certain will be the effect of any future defence work that may be necessary The four papers presented at the meeting of the British Association at York may be regarded as samples of the interest which coastal research is now provoking

J A STEERS

OBSERVATIONS OF THE RUSSIAN MOON ROCKET *LUNIK II*

THE 250-ft radio telescope at Jodrell Bank was used to receive the transmissions from the second Moon rocket launched by the U S S R Observations were made on the evenings of 1959 September 12 and 13 on frequencies of approximately 183 6 Mc /s and 19 992 Mc /s The only other part of the radio spectrum searched was in the region 19 99–20 01 Mc /s , but no signals from the probe were found

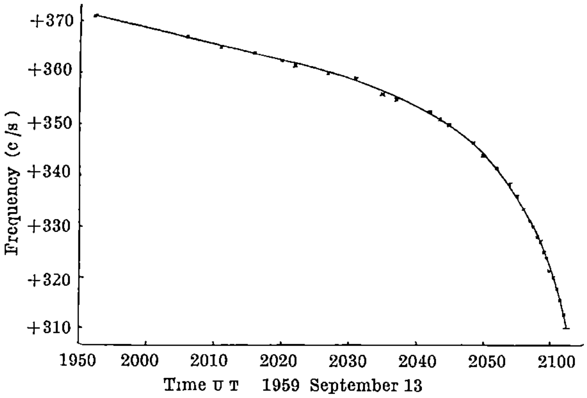

Fig 1 The variation of received frequency in cycles per second deviation from 19 992 Mc /s plotted for the last hour of the flight of *Lunik II*

The primary feeds consisted of a folded-wire dipole without reflector for the 20 Mc /s band and a folded dipole with reflector for 183 6 Mc /s The 183 6 Mc /s signal was received on a communication receiver with a band-width of 5 kc /s , and the 19 992 Mc /s on a receiver with variable band-width, 750 c /s being employed for most of the time Both frequencies carried the familiar bleep bleep' modulation pattern, and although clearly audible, the signals were not strong enough to permit reliable estimates of signal strength The signals on both frequencies ended abruptly and simultaneously at 21h 02m 23s U T on September 13

Within the limits of the 2° beam of the radio telescope at 183 Mc /s , and the rather heavy fading of the weak signals, there was no significant deviation of the position of the rocket from the predictions received from Moscow

The precise frequency of the 19 992 Mc /s signal was measured by comparison with a frequency standard to an accuracy of ±½ c /s On the evening of September 12 the measured frequency varied uniformly at 4 c /s per hour between 20h 30m and 22h 30m U T The rate expected from the effect of the Earth's rotation alone is about 6 c /s per hour, thus the rocket was at that time being slightly retarded by the Earth's gravitational attraction The variation in frequency over the final hour of the rocket's journey on September 13 is plotted in Fig 1 The smooth nature of this curve indicates that no guiding rockets were used during this period The slope of this curve is a direct measure of the line of sight acceleration and hence, using the Moon's mass, gives a maximum distance from the Moon for each point on the curve The acceleration at the end of the curve is that expected for an object moving directly towards the centre of the Moon at a height of 70 km ±150 km from the Moon's surface, and can therefore be taken as positive confirmation that the rocket did indeed hit the Moon somewhere within 7 minutes of arc from the centre of the lunar disk The velocity of impact derived from these data is approximately 3 km /sec ±0 5 km /sec

We are indebted to our Russian colleagues for computing the tracking data for the radio telescope

J G DAVIES
A C B LOVELL

Jodrell Bank Experimental Station,
University of Manchester

ON September 13, attempts were made to observe the impact of the Russian vehicle upon the Moon The telescope used was the 12 5-in reflector with which extensive lunar observation has been carried out since 1949

The impact area had been indicated as that of the Maria Serenitatis, Tranquillitatis and Vaporum Such an area would be impossible to cover adequately Since it seemed reasonable to assume that the Russians intended to land the vehicle as close as possible to the apparent centre of the lunar disk, it was considered best to use a reasonably high power (×300 to 400) and concentrate solely upon the Mare Vaporum region

Predicted impact time was 21h 01m U T Nothing was recorded at this time, but at 21h 02m 23s U T (±2 sec) a minute pinpoint of light was recorded , it appeared suddenly, and faded out within half a second The lunar co-ordinates are estimated as +085 +195 This places the position as in the Hyginus area, close to Schneckenberg

Though seeing conditions were good, the phenomenon was so uncertain and so close to the limit of visibility that it seemed unwise to trust it A report was at once sent to the Director of the Lunar Section of the British Astronomical Association, at Manchester, to await confirmation Since it now seems that both time and position are in good agreement with other observations, there is a possibility that the phenomenon did in fact represent the impact

PATRICK MOORE

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ON September 13, observations were made with the hope of observing the landing of the Russian *Lunik* on the Moon, using a reflecting telescope of 15¼-in aperture with a power of 300 The sky was very clear and surface details on the Moon clearly defined The Russians had said it was aimed at the Mare Tranquillitatis, Serenitatis and Vaporum, that is, the region to the north-west of the geometrical centre Last Sunday the Moon had sufficient libration to bring this region nearer to the centre as seen from the Earth than usual

This area of hundreds of square miles was 'swept' regularly The stated time for impact arrived and nothing was seen I decided to continue for a short while and 1½ min after the stated time, at 21h 02m 23s U T , I was looking at the Mare Vaporum, the nearest part to the centre At this point, north of the Hyginus Cleft and close to Schneckenberg, I observed a pinpoint of light and a kind of dark ring just as though dust had been disturbed and heated This lasted a few seconds

I understand that this observation is in accordance with the work of other observers

H PERCY WILKINS

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NEWS and VIEWS

Engineering in the University of Birmingham :

Prof G F Mucklow

PROF G F MUCKLOW retired this summer from the Chance chair of mechanical engineering, University of Birmingham He is succeeded by Dr S A Tobias, assistant director of research in the Department of Engineering, University of Cambridge Prof Mucklow has held the chair since 1940 He was educated at Rugby, McGill University and the University of Manchester He was for a short time a research associate of British Motor and Allied Manufacturers before taking up the post in 1923 as lecturer in engineering at the University of Manchester He is well known for his work on compression-ignition engines super-charging, exhaust pipe effects, wave-action in gases and related topics During his tenure of the Chance chair, the Department of Mechanical Engineering has been greatly expanded Prof Mucklow has played a prominent part in the development of postgraduate courses of instruction for men returning from industry The first course to be established was that in production engineering, and this was followed in 1950 by a most successful course in thermodynamics He has seen the Department rehoused in excellent buildings which were officially opened in 1954

Prof S. A Tobias

DR S A TOBIAS, who succeeds Prof Mucklow, was born in Vienna in 1930 He received his education at the University for Technological and Economic Sciences, Budapest, Hungary, and graduated in 1943 For four years after that he worked in industry as a design engineer of machine tools Tobias came to Britain in 1947 as a British Council Scholar, becoming a research student in the Department of Engineering, University of Edinburgh, where he received his Ph D in 1950 During 1951–54 he was an Imperial Chemical Industries research fellow at Edinburgh, working on problems of linear and non-linear vibrations, and received his D Sc Edinburgh in 1955 In that year he was appointed assistant director of research in the Department of Engineering, University of Cambridge, where he has built up a flourishing research school in the field of non-linear vibrations and in problems arising in metal-cutting processes

Agricultural Botany at Bangor

Prof Alun Roberts

PROF R ALUN ROBERTS is retiring from the chair of agricultural botany at the University College of North Wales, Bangor At Bangor the Departments of Agriculture, Agricultural Botany and Agricultural Chemistry are separate and independent, and, unlike most of the other universities where agriculture is taught, there are no subordinate professorships in those subjects Prof Alun Roberts was appointed professor at Bangor in 1945, where he had been independent lecturer in agricultural botany during 1921–40, when he was seconded as executive officer to the Caernarvonshire War Agricultural Executive Committee. His secondment was later transferred to the Welsh Department of the Ministry of Education, in order to study its problems in rural Wales. Plant ecology, especially of the grasslands of Snowdonia, has been the favourite subject of research of Prof Alun Roberts and his colleagues. His knowledge of early settlements and of Welsh history, enriched by long and close study of old estate manuscripts, enabled him to link up ecological changes with past land use. Particulars of early settlements, and later stocking of lowland and upland, with summer migration of the inhabitants from Hendre to Hafod, have added interest to his ecological studies. In addition to his scientific, historical and literary activities, he has found the time to serve on such bodies as the Royal Commission on Common Lands, the Welsh Land Sub-Commission and Nature Conservancy. His knowledge of land use, past and present, makes him a specially valuable member.

Prof J L. Harper

DR J L HARPER has been appointed to succeed Prof Alun Roberts. He gained honours in the final honours school of botany in 1946 at Magdalen College, Oxford, and was awarded the senior Mackinnon scholarship and a Department of Scientific and Industrial Research postgraduate scholarship. In 1949 he carried out research at the Imperial College of Tropical Agriculture and Colonial Microbiological Research Institute, Trinidad. He gained his D Phil in 1950 for his work in the interactions of soil micro-organisms. Dr Harper is a lecturer in agriculture at University College, Oxford, and has been a member of the Board of the Faculty of Agriculture and Forestry since 1957. While he has published much in the realms of plant pathology and of genetics, he is perhaps best known for his researches in experimental ecology. By inclination and practice he is an ecologist in the widest sense, and from an agricultural point of view, in matters of weeds, prefers to start with the biology of control rather than with chemical applications. Dr Harper, who gained a Rockefeller Foundation award, is at present working in the Department of Dr G Ledyard Stebbins, Davis University, California ; he will not take up his appointment at Bangor until next year.

Ministry of Agriculture, Fisheries and Food : Dr H R Barnell

THE Ministry of Agriculture, Fisheries and Food has announced the appointment of Dr H R Barnell as chief scientific adviser (food) in succession to Dr N C Wright (see *Nature*, 182, 631 ; 1958), who has been appointed to the office of deputy director-general of the Food and Agriculture Organization of the United Nations.

Dr Barnell was educated at Luton Grammar School and at Downing College, Cambridge. In 1929 he obtained first-class honours in the Natural Sciences Tripos Pt II (Botany) and was awarded the Frank Smart Prize. He was afterwards Frank Smart Student in botany. He was a research student in the Cambridge Department of Botany from 1929 to 1932. After a period as research assistant and lecturer in the Cambridge School of Agriculture he was appointed to the staff of the Low-Temperature Research Station of the Imperial College of Tropical Agriculture, Trinidad. His work in Cambridge was on the biochemistry of cereals, and in Trinidad primarily on the biochemistry of the banana in relation to the refrigerated and gas storage of tropical fruits. In 1943 he returned to the United Kingdom as a member of the Dehydration Division of the Ministry of Food, and was eventually transferred to the Scientific Adviser's Division, where he was primarily concerned with developments within fields of food science and technology. In this connexion he not only played a major part in developing the food aspects of Commonwealth defence science, but also was largely responsible for initiating and planning the programme of work of the Ministry's Experimental Factory and Research Establishment at Aberdeen. In 1950 he was appointed deputy chief scientific adviser.

In the course of his official work Dr Barnell has made wide and warm personal contacts throughout the food industry, not only in Britain but also overseas, where he has travelled extensively in North America, Central and South Africa, Australia and India. He has served on the governing bodies of a number of food industry's research associations, and was one of the Ministry's assessors on the Food Investigation Board of the Department of Scientific and Industrial Research. He is a member of council of the Institute of Biology. Dr Barnell's outstanding contributions in the building up of the Scientific Adviser's Division make his choice as chief scientific adviser a particularly appropriate one.

Difficulties in the Present Systems of Superannuation

A QUESTION was raised in the House of Commons on July 2 regarding difficulties in the exchange of teachers between universities and colleges of technology arising out of their differing schemes of superannuation. In reply Sir Edward Boyle, Parliamentary Secretary to the Ministry of Education, said that the possibility of transfer between the two superannuation systems had been exhaustively considered and found to be impracticable. There were, however, arrangements for integrating service under the two schemes and he believed these were not as widely understood as they might be. Sir Edward Boyle said he was investigating the matter. Transfer had proved impracticable because the pensions under the university scheme were based on an insurance policy and differed in content and kind from those under public service superannuation schemes. Mr Allen pointed out that to fill vacancies in the colleges of advanced technology and the regional technical colleges it will be necessary to go to the universities for the senior posts. However, at present the difference between the two schemes was causing many suitable university candidates to decline posts as principals and heads of departments in colleges of technology.

The Zero Gradient Synchrotron

IN a press report dated June 27, 1959, the U S Atomic Energy Commission gives details of a large orbital accelerator for protons, to be constructed at the Argonne National Laboratory, Lemont, Illinois. Economic factors always entail a compromise between high energy and high intensity in proton synchrotrons, but improvements in design may materially enhance the output obtainable at a given cost. The technical advance known as alternating-gradient focusing led to the design of the 25 GeV proton accelerators at Cern, Geneva, and at Brookhaven, but these machines may prove to be limited in beam intensity to about 10^{11} particles per acceleration pulse. In the Argonne Laboratory machine, gradient focusing is not used and the uniform guiding magnetic field is forced beyond the saturation value over a vacuum system of relatively large aperture. Beam stability is obtained by wedge-focusing effects at the boundaries of the sectors into which the 200-ft. diameter magnet ring is divided. As a result of the fairly large aperture and high injection energy (50 MeV.), pulses of about 10^{12} protons of an energy of 12.5 GeV. are expected. Much of this beam should be available outside the machine.

The Argonne Zero Gradient Synchrotron and its associated equipment will cost 29 million dollars. It will provide a strong source of all known particles and anti-particles and, since it will be especially suited to the study of rare events, it may lead to the discovery of new phenomena. The cost of such research now far exceeds the resources of individual institutions, and the development of great national or international laboratories, in which many university teams conduct research with one accelerator, is a natural consequence. The new undertaking at Argonne, which it is hoped to complete during 1962–63, has many similarities to that at Harwell, where a 7 GeV. proton synchrotron is under construction for the National Institute for Research in Nuclear Science.

Higher Education in the U.S.S.R.

A BIBLIOGRAPHICAL survey of technical and vocational education in the U.S.S.R. by M. I. Movšovič, issued as No. 30 of educational studies and documents by the United Nations Educational Scientific and Cultural Organization (Technical and Vocational Education in the U.S.S.R.: a Bibliographical Survey. By M. I. Movšovič. Pp. 53. Paris: Unesco; London: H.M. Stationery Office, 1959. 5*s.* net), covers vocational education at the elementary, secondary and higher levels. Besides books and articles, bibliographies and periodicals are dealt with in a separate section. Generally, publications are presented chronologically within each section and the articles are fairly fully annotated or summarized.

Planning in Pakistan

A BROADSHEET, "Planning in Pakistan" (*Planning*, Vol. 25, No. 433, April 20, 1959. Pp. 85–112. London: Political and Economic Planning, 1959. 2*s.* 6*d.*), which emphasizes the stimulus to central economic planning derived in the new countries of Asia from independence and the prospect of foreign aid, gives a clear but concise account of the progress of planning in Pakistan. After reviewing the effects of partition and planning in the early years, the broadsheet outlines the Five Year Plan, published in May 1956 by the Pakistan Planning Board established in July 1953, and then describes the performance and prospects of the plan. Political and Economic Planning concludes that although Pakistan is passing through a difficult phase in its economic, as in its political, development, it is tackling its difficulties with vigour. Performance, however, in some spheres remarkably good, has been uneven, and, regarded as a whole, inadequate. Big mistakes have been made, particularly because of over-ambitious schemes, and too optimistic assumptions about foreign exchange and sterling earnings, and import savings. Brilliant results in industrial development do not balance the failure to develop agriculture. Nevertheless, Pakistan's economy is basically sound. It is learning from past errors and preserving its zeal to plan and work for prosperity.

International Council of Museums

THE fifth General Conference of the International Council of Museums was held in Stockholm during July 1–8 under the presidency of Dr. Georges Salles (France). The Conference was preceded by meetings of certain committees and commissions held at Oslo and Copenhagen. Dr. Torsten Althin was chairman of the Swedish National Committee which carried out all the complicated organization for the meeting. About 350 delegates attended. The theme of the Conference and the lectures was "Museums as Mirrors—their Potentialities and Limitations". An important session dealt with the inauguration of the International Centre for the study of the preservation and restoration of cultural property. This Centre, established in Rome by the General Conference of Unesco, is designed to strengthen relations between all who are interested in the preservation of their cultural traditions. Dr. H. J. Plenderleith, recently of the British Museum, has been appointed the first director, and at Stockholm he outlined the policy of this new Centre. It aims to collect documentation on the efforts already made in this field, co-ordinate research in order to avoid overlapping, and give advice to all those requesting it. The Centre will also assist and facilitate the training of experts and is destined to become the institution best informed about the results already achieved and the research in progress. The foremost requirement at present is that the great countries should support this venture and ensure its existence after the period guaranteed by Unesco. It was agreed that the next triennial conference should take place in Holland in 1962 under the presidency of Sir Philip Hendy (National Gallery, London).

Geophysical Journal

THE appearance of the first number of the second volume of the *Geophysical Journal*, published by the Royal Astronomical Society, is a suitable opportunity to stress the contribution which this journal is making to the growth of pure geophysical research, especially in Great Britain. The fundamental importance of the papers, the careful refereeing and the speedy publication are heartening. Half this particular number contains original material. The other half consists mainly of a review of palæomagnetism and two shorter reports, one on a geophysical meeting and one on current geophysical research in Canada.

The Australian Journal of Statistics

THE Statistical Society of New South Wales is publishing a new journal, namely, *The Australian Journal of Statistics*. It is to be issued three times a year, and will contain material relating to statistical theory and methods and their application to all branches of learning. The *Journal* will give Australian statisticians an opportunity to present their work to the public without undue delay. The editor is H. O. Lancaster. The first number runs to thirty-four pages, and besides introductory material and a "News and Notes" page, contains three papers. The price of this number is 10*s.*, which is perhaps a little high for such a slim volume, but even so the Society has had to have outside financial support from some dozen organizations. The *Journal* will no doubt satisfy a need among Australian statisticians, who are making valuable contributions to the development of statistics, and every success is to be wished to the Society in its new venture.

Soviet Rubber Technology

The appearance of a regular translation of the monthly Soviet journal *Kauchuk i Rezina* under the title *Soviet Rubber Technology* (No 1, June 1959 English translation of *Kauchuk i Rezina*, Vol 18, January 1959 Pp 64 Annual subscription rates Ordinary, U K £10 10*s* Abroad 50 U S dollars, or equivalent R A B R M Members and U K non-profit-making institutions £5 5*s* Obtainable from Maclaren and Sons, Ltd , 131 Great Suffolk Street, London, S E 1) is a welcome addition to the scientific literature of the U S S R available in the English language The translation, which is being carried out by the Research Association of British Rubber Manufacturers under the auspices of the Department of Scientific and Industrial Research Translations Unit, combines technical competence and accuracy with a pleasant and readable style It is stated that the journal "deals with the efficient use of raw material, the automation of manufacturing processes in the rubber industry and improvements to the design of tyres and industrial rubber goods Articles describing the most important chemical research of interest to the rubber industry are also included" The first issue includes, in addition to original research contributions, more general articles reviewing industrial organization in the U S S R , and news items The scientific papers are about equally divided between chemistry (polymerization processes, compounding, vulcanization, etc) and physics (properties of rubber compounds, fatigue and adhesion of tyre cord, etc) The journal gives a good general insight into the technical and industrial problems of the Soviet rubber industry

The Wellcome Trust

The second report of the Wellcome Trust covers the period September 1, 1956–August 31, 1958 (Pp 72+3 plates London The Wellcome Trust, 1959), in which £1,059,919 was allocated by the Trustees, compared with £1,170,164 in the twenty years 1937–56 covered by the first report The fourth and final report on the findings of the Wellcome Marston Archæological Research Expedition to the Near East, published in June 1958, deals further with excavations undertaken by the late Mr J L Starkey and others at a mound known as Tell el-Duwier, about half-way between Jerusalem and Gaza Total expenditure by the Trustees on the Lachish expedition, including costs of publication, has amounted to £35,496 During the period 1956–58 grants made in aid of research in human and animal medicine and the contributory sciences have totalled £925,357 In making these grants the Trustees have followed their previous policy of supporting enterprises the merits of which were endorsed by the best available scientific opinion, but which had not hitherto received the help they needed Priority was given to tropical medicine, pharmacology, pharmacy, therapeutics, veterinary medicine and the history of medicine The report contains a full list of research grants and of travel grants during the period Travel grants were made to 167 research workers, expenditure increasing from £11,410 in 1955–56 to £20,022 in 1957–58 and in addition five block grants were made to the organizing committees of international congresses or of smaller specialist symposia abroad, bringing the total expenditure to £42,175 on 257 persons in the period The Trustees have also instituted a system with the Carlsberg Foundation of 'Carlsberg-Wellcome Travelling Research Fellowships' to encourage friendly co-operation on an exchange basis between Danish and British research workers in sciences bearing on human and animal medicine and two fellowships were awarded in each of the academic years 1957–58 and 1958–59 Capital grants for building projects during the period amounted to £543,500, with a further £115,160 to assist medical research libraries and museums, which included some building projects, and a further £171,065 allocated for expenditure on major items of research equipment In support or endowment of senior research posts the Trustees allocated £72,983, and towards various grants for research expenses and assistance, £25,107 New grants totalling £3,932 were made for work in the history of medicine and £957 to assist other scientific publications A grant was made to the Royal College of Physicians to cover the expected cost of producing a new edition of the 1928 Harvey film, by the use of colour photography, synchronized sound-track, animated diagrams and other appropriate improvements of cinematographic technique

English Rural Life

The Report of the Museum of English Rural Life for 1958 (University of Reading Museum of English Rural Life—Report 1958 Pp 24 Reading The University, 1959 1*s*) is far from formal, for it includes, in fact is mainly devoted to, a summary of the principles of display in a museum This part is contributed by Miss Margaret Fuller and Mr C A Jewell and is of interest and value to all museum curators especially those who deal with the difficult problem of exhibiting folk-life material In this report the policy of the Museum in relation to other regional museums is more clearly defined than it has been in the past and it is noted that it states its major task to be the formation of a national archive of information on all aspects of country life It is hoped that in the future a considerable proportion of the objects in the Museum will be available to supplement other collections or to form the nucleus of new folk sections.

Genetical Effects of Population Subdivision

P A P Moran has advanced a theory relating to some genetical effects of population subdivision (*Australian J Biol Sci* , 12, 2, 109 (1959)) The genetical effects of the subdivision of a population into partially isolated subgroups are considered in two particular cases In the first a probability model is studied in which the subpopulations are of finite size with migration between them In the absence of selection, the asymptotic rate of progress to homozygosity is shown to be very little affected by the subdivision In the second case a deterministic model is studied in which there are two subpopulations in which selective forces are equal and opposite. A stable dimorphism is then shown to exist if there is any small amount of intermigration

Fine Structure in Cells

G Setterfield, H Stern and F B Johnston have given an account of the fine structure in cells of pea and wheat embryos, based on observations using phase-contrast and electron microscopes (*Canadian Journal of Botany*, 37, 65 (1959)) The aim was to provide a basis for relating biochemical data on isolated cell fractions with the cytological structure *in situ* Pertinent observations include the following

The nuclei of all cells were similar, showing nuclear membranes, chromosomes, and prominent nucleoli. The cytoplasm contained highly developed structure which presumably reflected the incipient growth condition of the cells. Several cytoplasmic components were common to both embryos: small dense granules, endoplasmic reticulum, mitochondria, proplastids, amyloplasts, irregular bodies, plasma membranes, and plasmodesmata. The small dense granules, presumably ribonucleoprotein particles, occurred profusely, both free and in association with extensively developed endoplasmic reticulum. These particles are probably responsible for the microsomal fractions obtainable from embryos and seedlings. The mitochondria were usually relatively small (0·25–0·5μ diameter) although groups of very long (5μ) ones were occasionally found. Bodies resembling mitochondria in size and shape, but lacking cristae, were present and represent either immature mitochondria or proplastids. Reserve material occurred as starch in structurally complex amyloplasts and possibly as protein in the irregular bodies. In addition to these structures cells of the wheat embryos remote from the meristems contained prominent cytoplasmic bodies classified as 'dense' and 'thick-walled'. The dense bodies probably represent stored lipids while the significance of the thick-walled bodies, which showed a variety of forms, is unknown.

Rafflesia in Sumatra

AMONG the genera of plants which might well be described as wonderful, if not odd, *Rafflesia* must surely be accorded a leading place. Some thirteen species were recorded by Koorders in 1918 for the whole of the Malaysian region; but it now appears that some of this investigator's views may require revision. W. Meijer (*Ann. Bogoriensis*, 3, 1, 33 (1958)) has now added further information on *Rafflesia arnoldi* as observed by himself and colleagues in West Sumatra. From an examination of the literature and the material preserved in the Herbarium Bogoriense, as well as from his own observations, he has concluded that the *Rafflesia* species in question is identical with the original *R. arnoldi* of Robert Brown (1822) and that it occurs in both Central and South Sumatra. Its taxonomic position is discussed, and the author points out that *R. tuan-mudae* Becc. from Borneo is very closely related to, and may even be conspecific with, *R. arnoldi* R. Br., and that the key given in Koorders's monograph is incorrect as to the distinction between these two plants. Some information concerning other *Rafflesia* species occurring on Sumatra is also given. Observations on the growth-rate, mortality of the buds, and the possible mode of distribution of the seeds are recorded. It is now estimated that the entire cycle from seed to seed takes approximately 4½–5 yr.

Soil Basidiomycetes

J. H. WARCUP has contributed the results of an investigation on the isolation of basidiomycetes from the soil (*Trans. Brit. Myc. Soc.*, 42, 1, 45 (1959)). Whereas extensive series of dilution and soil plates from wheat-field and pasture soils failed to reveal these fungi, they were isolated from roots, and from hyphae, rhizomorphs, and sclerotia picked out from soil. Over a three-year period, no basidiomycete fructifications were found in the wheat-field although isolations from soil and roots showed that the field had an abundant and varied population of basidiomycetes. While fructifications were obtained from the pasture, the species thus seen fruiting were different from those isolated from soil and roots, indicating that the population was more varied than the fructifications alone would suggest. Some of the basidiomycetes were induced to form fructifications in culture.

Histological Localization of Peroxidase

D. S. VAN FLEET (*Canadian J. Bot.*, 37, 3, 449 (1959)) has observed that peroxidase is detectable in all tissues but is most reactive in the basophilic cells of the histogens. Oxidation of applied phenols and aminophenols by peroxidase produces quinones and quinonediimines that are adsorbed by nucleic acids and other basophilic substances in the formative centres of primordia. Localized reactions for peroxidase occur in the axils of leaf primordia prior to bud formation and on the surface of apical meristems in a spiral pattern marking the points for the future development of leaf primordia. Peroxidase is detectable in advance of or accompanying cell division and declines after the division phase; decline of peroxidase at the end of the division phase is related to the increase of phenols, naphthols and phenolases. Peroxidase declines in all tissues with the exception of the phloem; a continuous peroxidase system in the phloem connects primordia with adult tissue. The hypothesis is offered that the cellular units of the phloem peroxidase constitute a continuous system between primordia and adult tissue and are functional in catalysing the reduction of hydrogen acceptors essential to cell division and the initiation of primordia.

Oxidation of Krebs Cycle Acids by Apple Tissue

M. D. Hatch, J. A. Pearson, A. Millerd and R. N. Robertson, in a study of the oxidation of Krebs cycle acids by tissue slices and cytoplasmic particles from apple fruit (*Australian J. Biol. Sci.*, 12, 2, 167 (1959)), point out that it has hitherto been difficult to demonstrate the Krebs cycle in either cytoplasmic particles or tissue slices obtained from apple fruit. In the present investigation, evidence was obtained for the operation of the classical Krebs cycle–cytochrome oxidase respiratory system in cut tissue and mitochondria from Granny Smith apples. The respiration of cut tissue increased when either citrate, α-ketoglutarate, succinate, malate, fumarate, or pyruvate were added. Both the endogenous and acid-stimulated respiration were inhibited by malonate, cyanide, and azide. The rapid oxidation of Krebs cycle acids by cytoplasmic particles from apple flesh was also demonstrated. These particles showed cytochrome oxidase activity and contained a succinoxidase system dependent on cytochrome *c*.

Radiation in Industry

ARTHUR D. LITTLE, INC., undertook during 1958 a study of the anticipated need for high-level radiation sources and their potential uses in industry, on behalf of the CEM group of companies (Emerson Radio and Phonographic Corporation, General Airline and Film Corporation, and Revere Copper and Brass, Inc.) and the General Electric Company's Hanford Atomic Products Operation. A summarized version of the firm's report was given by S. E. Eaton and M. Michaelis at the seventh annual conference of Atomic Energy in Industry (Radiation: a Tool for Industry. Pp. i+28. Cambridge, Mass.: Arthur D. Little, Inc., 1959), held by the National Industrial Conference Board, Inc., at Cleveland, Ohio, during

April 8–10, 1959 The study was restricted to a survey and analysis of the available technological data and consisted of an examination of some 2,500 articles published during the past ten years and a series of some 330 interviews with leading workers in the field The pattern of current industrial activity in the applications of penetrating high-intensity ionizing radiations , present-day radiation costs , and radiation applications to chemicals and petroleum, to polymers, to pharmaceutical products, medical supplies and food, to power sources, and to miscellaneous substances such as semiconductors, are separately discussed Much basic work has been done on relatively simple systems, but more research on basic reaction mechanisms and more and better research equipment are required There is a considerable lack of knowledge both among industrial scientists and by the general public on the subject of radiation, its benefits, and the safeguards against its possible hazards Future long-term research on the effect of radiation on systems held at very low temperatures and very high pressures , the development of new techniques in solid catalyst activation , and the study of the usefulness of low-energy radiation in the 1–1,000 eV range, are some of the recommendations in the report It is emphasized that work up to date has been largely empirical, that possible unique features of radiation applications have not yet been fully explored, and that even radiation engineering is relatively undeveloped and radiation economics uncertain

Nobelium Research

In 1957 P R Fields and others reported the production at Stockholm of an isotope of element 102 in experiments in which curium targets were bombarded with cyclotron-accelerated $^{13}C^{4+}$ ions (*Nature*, **180**, 1010 and 1012, 1957) Two other groups have since reported experiments on the production of element 102 At Berkeley, A Ghiorso *et al* bombarded curium with carbon-12 and carbon-13 ions accelerated in *Hilac*, but did not observe the 102-isotope reported by Fields *et al* They detected and identified the presence of the isotope $^{254}102$ which has a half-life of three seconds In Moscow, G N Flerov and co-workers, by bombarding plutonium-241 with $^{16}O^{6+}$ ions, observed a short-lived product emitting long-range alpha particles with an energy of 8 8 ± 0 5 MeV which they ascribe to an isotope of element 102 Because of the negative results at Berkeley, Fields and his co-workers have recently made a thorough re-examination of their experimental data, and their comments and discussion on the Berkeley and Stockholm experiments are given in a paper in the *Arkiv for Fysik*, **15**, 225 (1959) They conclude that though their earlier mass assignment made in 1957 seems now less certain, nevertheless their re-examination has not led to any new conclusions regarding the interpretation of their results It is felt that judgment on the discovery of the element 102 should be reserved until additional experimental studies, including the properties of neighbouring nuclides, have been carried out

Borden Award of the Nutrition Society of Canada

The Nutrition Society of Canada has announced that the Borden award of the Nutrition Society of Canada will be given annually in recognition of outstanding research work done by one of its members The first award will be made in June 1960 The recipient of this award, which has been presented by the Borden Company Foundation, Inc , must be under the age of forty years and must have published the meritorious work within the preceding three years It is hoped that this award will further encourage research activities by younger members of the Society

Lady Tata Memorial Trust

The Trustees of the Lady Tata Memorial Trust, on the recommendation of the (European) Scientific Advisory Committee, have made the following awards for research on leukæmia and allied diseases in the academic year beginning October 1, 1959 *Grants for Research Expenses* Dr M Bessis (France), Centre National de Transfusion Sanguine, Paris , Dr B M Braganca (India), Indian Cancer Research Centre, Bombay , Prof G Klein (Sweden), Karolinska Institute, Stockholm , Dr J Pontén (Sweden), Pathology Institute, Uppsala , Dr M Simonsen (Denmark), Institute of Pathological Anatomy, Copenhagen , Dr A E Stuart (Scotland), Department of Pathology, University of Edinburgh , *Scholarships* Dr J Hastrup (Denmark), Institute of General Pathology, Aarhus , Dr E Kelemen (Hungary), Postgraduate School of Medicine, Budapest, Dr P A Pillai (India), Centre de Microscopie Electronique, Lausanne, Switzerland

Paul Instrument Fund Awards

Awards by the Paul Instrument Fund Committee of the Royal Society have been made as follows £1,000 to Dr H B Barlow, assistant director of research, Department of Physiology, and Mr P E K Donaldson, technical officer, Physiological Laboratory, Cambridge, for the development (*a*) of a device for automatically improving coding of messages, and (*b*) of a diffused storage sequence engine, the object being to advance knowledge of the operation of comparatively simple assemblies of nerve cells by making instruments which perform the same task as such assemblies , £600, in supplement of a previous grant, to Dr E T. Hall, senior research officer at the Research Laboratory for Archæology and the History of Art, Oxford, for improvements to an apparatus with which magnetic measurements may be made with the view of dating archæological material , £2,000 to Dr H Motz, reader in engineering science, University of Oxford (in association with Prof G B Walker, professor of electrical engineering, Essex College, Assumption University, Windsor, Ontario), for the construction of a linear accelerator working at 1 6 cm (*J*-band) , £5,500 to Prof R O Redman, professor of astrophysics in the University of Cambridge, for the construction and testing of a thin astronomical mirror of plate glass and of a new type of support system , £5,900 to Dr P M B Walker, Royal Society Research Fellow, Department of Zoology, Ashworth Laboratory, University of Edinburgh, for the construction of a new microspectrophotometer that will integrate over a defined but irregular area which can be altered quickly and easily

Grant for the Massachusetts Institute of Technology

Dr Julius A Stratton, president of the Massachusetts Institute of Technology, announced recently that the Institute had received a gift of

2,527,500 dollars (about £900,000) from Mr and Mrs C H Green of Dallas, Texas This represents the March 31 market value of 30,000 shares of stock of Texas Instruments Inc, in which form the gift was made The money will be used to construct a multi-story building on the Institute site, and will be a centre for the study of Earth sciences Laboratories for research work in geophysics, meteorology, oceanography and related fields will form an important part of the new building

University News: London

Dr P Grootenhuis, lecturer at the Imperial College of Science and Technology, has been appointed to the University readership in mechanical engineering tenable at that College The title of reader in sociology in the University of London has been conferred on Mr T B Bottomore, in respect of his post at the London School of Economics and Political Science The title of professor emeritus in the University has been conferred on Prof R J S McDowall on his retirement from the Halliburton chair of physiology at King's College, Prof Margaret M A Murray on her retirement from the chair of physiology at Bedford College, Prof J H Woodger on his retirement from the professorship of biology at the Middlesex Hospital Medical School, and Prof H J Collins, on his retirement from the Chadwick chair of civil engineering at University College

University College of Rhodesia and Nyasaland

Mr W Lloyd Jenkins has been appointed lecturer in the Department of Chemistry with responsibility for teaching agricultural chemistry Previously he was a lecturer in agricultural chemistry in the University College of Wales, Aberystwyth

The Night Sky in October

New moon occurs on Oct 2d 12h 31m U T, full moon on Oct 16d 15h 58m, and new moon on Oct 31d 22h 41m The following conjunctions with the Moon take place Oct 6d 00h, Jupiter 4° S, Oct 8d 05h, Saturn 5° S, Oct 28d 14h, Venus 0 9° N In addition to these conjunctions with the Moon, Venus is in conjunction with Regulus on Oct 1d 08h, Venus being 5 7° S, and Mercury with Spica on Oct 4d 09h, Mercury being 2 1° N There will be a total eclipse of the Sun on October 2, visible as a partial eclipse at Greenwich The path of totality begins at sunrise on the eastern seaboard of the United States, crosses the North Atlantic, Canary Islands and North Africa, ending in the western Indian Ocean at sunset The partial eclipse which will be seen at Greenwich begins at 11h 01m, reaches its greatest magnitude of 0 33 at 11h 58m and ends at 12h 56m The eclipse belongs to a series which began in 1599 Mercury is too close to the Sun for observation Venus is a morning star, rising at 2h 55m, 2h 30m and 2h 35m on October 1, 15 and 31, respectively Its stellar magnitude is approximately −4 3, greatest brilliancy is reached on October 8 Its distance increases during the month from 36 to 55 million miles and the visible portion of the apparent disk increases from 0 211 to 0 443 Mars is too close to the Sun for observation, conjunction being on October 29 Jupiter is also too close to the Sun for observation. Saturn sets at 21h 20m, 20h 25m and 19h 30m on October 1, 15 and 31, respectively Its stellar magnitude is +0 8, it remains in Sagittarius Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich Oct 10d 20h 13 4m, τ Cap m (*D*), Oct 17d 20h 04 4m, ξ Ari (*R*), Oct 20d 23h 35 1m, 318 B Tau (*R*), Oct 21d 23h 38 6m, 130 Tau (*R*), Oct 28d 4h 22 0m, 58 Leo (*R*) *D* and *R* refer to disappearance and reappearance, respectively The Giacobinids are active on October 9 and the Orionids during the third week of the month, conditions for both are unfavourable

Announcements

Lord Netherthorpe, president of the National Farmers' Union, and Prof F W Rogers Brambell, professor of zoology in the University College of North Wales, Bangor, have been appointed to fill vacancies in the membership of the Agricultural Research Council caused by the retirement of Sir Solly Zuckerman and Mr Frank Rayns

Dr A G Ogston has resigned from the chairmanship of the Editorial Board of the *Biochemical Journal* and the Committee of the Biochemical Society has appointed Dr W V Thorpe as his successor Correspondence and communications should still be sent to the Secretary to the Editorial Board, Lister Institute of Preventive Medicine, Chelsea Bridge Road, London, S W 1

The following officers of the Association of Consulting Scientists have been elected. *Chairman,* Dr J G Davis, Hon Treasurer, Dr G W Ferguson, Hon Secretary, Mr W H Stevens, 15 Hawthorne Road, Bromley, Kent

A meeting will be held on October 31 at the University of Nottingham with the object of forming a Society for Forensic Science Further information can be obtained from Mr S S Kind, 18 Hall Lane, Harrogate, Yorkshire

The eighth German Plastics Convention will take the form of an International Symposium on the Ageing of Plastics, it will be held during October 19–21 at Dusseldorf, Germany Further information can be obtained from the Arbeitsgemeinschaft Deutsche Kunststoff-Industrie, Frankfurt (Main), Karlstr 21

The German Society for Electronmicroscopy is holding a conference on various aspects of electronmicroscopy at the Departments of Pathology and Anatomy, Albert-Ludwigs-University, Freiberg im Breisgau, Germany, during October 18–21. Further information can be obtained from Tagung der Deutschen Gesellschaft fur Elektronenmikroskopie e V Pathologisches Institut der Universitat, Freiburg, Albertstr 19

The City of London College, in collaboration with the Plastics Institute, has arranged a series of eight lectures on plastics which will be given on successive Mondays at the College, commencing on October 5 Further information can be obtained from Mr A Fawthrop, head of the Department of Shipping and Commercial Products, City of London College, London E C 2

Erratum The author of the communication "Appearance of Granules in the Cytoplasm of Tumour-cell Cultures in Contact with Lysozyme" in *Nature* of July 18, p 202, is Mrs Dirce Babudieri Callerio, and not Prof Carlo Callerio as printed

FLUCTUATION PHENOMENA AND STOCHASTIC PROCESSES

THE theory of probability developed as a branch of pure mathematics Its applications to physics have now become so widespread that there is scarcely a branch to which it does not contribute significantly During the nineteenth century the establishment of the statistical nature of the second law of thermodynamics, the resolution of the irreversibility paradox, and the development of the powerful technique of statistical mechanics were all the result of applying statistical methods to an atomic population In the twentieth century the wave-particle paradox was solved by rooting atomic physics in the theory of probability At a less fundamental level, Brownian movement, diffusion and radio noise are physical phenomena the character of which is essentially stochastic , and radio-wave propagation, sea waves, nuclear reactors and polymer physics are examples of fields in which stochastic problems have recently attracted considerable attention

The apparatus of the mathematician has been accepted with gratitude by the physicist generating functions and characteristic functions for manipulating probability distributions , generalized Fourier analysis introducing autocorrelation functions, and leading to the Wiener–Khintchine theorem for fluctuation phenomena stationary in time In return the physicist has continually thrown up a variety of novel problems to challenge the ingenuity of the mathematician and maintain his interest

The two-day conference of the Physical Society on "Fluctuation Phenomena and Stochastic Processes", held at Birkbeck College on March 19 and 20, attracted research workers in many different fields Altogether, twenty-nine papers were presented , most of the participants were British, although contributions also came from the United States, Canada and Norway

In his opening remarks of welcome, Prof J D Bernal (Birkbeck College, London) pointed out that physics had learnt to deal adequately with the completely regular, and the completely random , it was the partially regular which still awaited treatment The nature of the liquid state, and biophysical problems connected with the structure of large molecules, were important examples of this

In the opening paper, Prof M S Bartlett (University of Manchester) reviewed the various types of statistical fluctuations which occurred in physics, and attempted to classify them in order of relative size In spite of the existence of occasional abnormal fluctuations, macroscopic averages in classical statistical mechanics had a 'stability' resulting from the large number of component systems involved The measurement of time and space averages for phenomena such as turbulence and random surface waves, on the other hand, made use of the ergodic properties of some stationary processes A fairly general 'weighted sum' type of process occurring in noise and Brownian motion theory was defined, together with the conditions for statistical 'stability' Finally, there was the class of possibly exponentially increasing and unstable multiplicative (branching) processes such as nuclear cascades

Dr R Furth (Birkbeck College) gave a comprehensive paper entitled "Fluctuations of Macroscopic Parameters" Macroscopic parameters ξ_i were operationally defined in finite regions Δs, of space and finite intervals Δt, of time of such magnitude that irregular fluctuations could be observed superimposed over the regular quasi-continuous functions $\xi_i(r,t)$ The theory of these fluctuations was mainly concerned with the determination of the second moments of the temporal fluctuations of the parameters ξ_i in a fixed Δs, and of the spatial fluctuations in one and the same Δt It was a characteristic feature of the theory that these moments could be expressed in terms of the macroscopic functions, $\xi_i(r,t)$, and that only some very general statistical properties of the random molecular processes responsible for the fluctuations needed to be known

In the temporal problem the correlation functions of the type $c_s(\tau) = [\overline{\xi_i(\tau)\xi_j(t+\tau)}]_s/(\overline{\xi_i\xi_j})_s$ could be calculated by making use of a generalized 'Langevin equation' , in the limiting case of $\tau = 0$ the second moments $(\overline{\xi_i\xi_j})_s$ might be obtained under conditions of statistical stationarity from statistical mechanics This latter procedure could be applied to the problem of fluctuations of strain and stress in crystalline solids

In the problem of spatial fluctuations the same method of statistical mechanics could be used for evaluating the spatial correlation products $[\overline{\xi_i(x)\xi_j(x+\zeta)}]_t$ of two parameters in two regions $(\Delta s)_1$ and $(\Delta s)_2$ in a homogeneous medium, separated by a distance ζ under conditions of 'quasi-stationarity', that is, when in spite of the finite speed of propagation of the interaction processes the values $\xi(x)$ and $\xi_j(x+\zeta)$ could be assumed to be simultaneous to a sufficient degree of approximation This method could be used to obtain formulæ for the fluctuations of electric charge and potential in a discontinuous system of conductors , and had been applied by E Morris to the problem of fluctuations of surface charge density on the surface of a single continuous conductor, and the fluctuations of potential on and outside its surface

Finally, the general problem of spatial fluctuations could be reduced to that of temporal fluctuations in such cases where the relevant Langevin equation had the character of a wave equation. This method was used by M N Moore for the solution of the problem of spatial fluctuations of strain and stress in crystalline solids

Several papers dealt with the mathematical properties of stochastic functions, and with their application to the analysis of experimental data Mr D G Brennan (Massachusetts Institute of Technology, Lincoln Laboratory) in a paper entitled "A New Approach to Certain Types of Random Functions" developed *ab initio* a theory of a class of stochastic processes which he hoped would have application to certain types of physical problem Mr M B Priestley (University of Manchester) considered the problem of detecting a signal containing several harmonic components in the presence of background noise When the noise had a uniform spectrum the appropriate quantity for picking out the harmonic terms was the periodogram But when the spectrum of the noise was non-uniform this could no longer be used, and he proposed a method of analysis based on the tail of the auto-correlation function. He also showed how a significance test could be constructed.

Mr. B. Landmark (Norwegian Defence Research Establishment) dealt with the provision of a stringent test for the Gaussian character of a given noise signal. An amplitude test was usually insufficient, and he suggested using the simultaneous variations in amplitude and phase. This had been applied experimentally to the scattering from ionospheric clouds[1], and the results were in good agreement with those to be expected for Gaussian noise.

Dr. L. Mandel (Imperial College of Science and Technology, London) gave an interesting example of a problem in which the approach of the quantum theory produced a substantial simplification. The distribution of the integral, E_T, over a time interval T of the square of random noise was quite complicated, and some of its properties had been deduced by Rice[2]. If we interpreted the noise as arising from an electromagnetic wave, E_T was proportional to the energy contained in a length cT of the wave train. Bose–Einstein statistics could be applied to the photons in this region, and the resulting probability distribution could be determined more readily.

The statistics of radioactive decay was the subject of a communication by Mr. A. C. Hughes. He was concerned with testing fluctuation theory for short-lived substances, that is, those with half-lives short compared with the time of observation. Experiments had been performed with an isotope of rhodium (half-life 44 sec.), and two isotopes of silver (half-lives 24 sec. and 2·3 min.); the agreement with theory was good.

Dr. M. N. Moore (Birkbeck College) spoke on the "Stochastic Kinetics of Nuclear Reactors". It could be shown that the square of the modulus of the reactor transfer function was proportional to the Fourier transform of the auto-correlation function for power noise in the reactor. Since the power noise represented the response to the minimum power input signal, measurements of transfer functions based upon reactor noise were of all possible measurements least subject to non-linear distortion. By performing the experiment at various power-levels and temperatures, it was possible to measure both power and temperature coefficients[3].

Some examples were given of new problems in probability which had been suggested by physical phenomena. Prof. C. Domb (King's College, London) said that if one wished to understand what was happening in a regular solution, one must study its fluctuation properties, or the distribution of clusters of different sizes and shapes as a function of temperature. Even for a purely random mixture this was very difficult, although one could readily establish a difference in behaviour in one, two or three dimensions. Thus for a 50 : 50 mixture if one considered clusters of up to 5 atoms, 88 per cent of the total number were accounted for in one dimension, 17 per cent in two dimensions and only 2 per cent in three dimensions. A critical probability entered in these problems in the same manner as those studied by Hammersley[4].

Dr. M. E. Fisher (King's College, London) discussed the shapes and sizes of polymer and polyelectrolyte molecules which seriously affected properties like viscosity. We should be greatly assisted in this field by a knowledge of the properties of non-intersecting random walks on lattices. These walks were non-Markovian and their behaviour probably differed essentially from Markovian walks. The only property which had been rigorously established[5] was that C_n, the total number of walks of n steps, was asymptotically of order μ^n. Some conjectures on the value of μ for a quadratic lattice had been rigorously disproved[6]. The subject suffered seriously from a lack of theorems of the 'central limit' kind. Dr. M. F. Sykes (King's College, London) dealt with methods for the practical determination of parameters in self-avoiding walks. Monte-Carlo methods had been used extensively by Wall and his collaborators[7], but Sykes and his colleagues had preferred to determine the properties exactly for finite values of n, rather than to attempt asymptotic extrapolation. When n was larger than about 10, irregular variations were small, and one could put forward the results with confidence. He estimated that for a quadratic lattice $c_n \sim n^{1/3}\mu^n$, where $\mu \simeq 2{\cdot}640$ (with a probable error $<\frac{1}{4}$ per cent). Also there was strong evidence that if p_n is the number of simple closed polygon walks of n steps, then ${p_n}^{1/n} \to \mu$.

Mr. J. M. Hammersley (Atomic Energy Research Establishment, Harwell) spoke on "Percolation Processes"[4]. These differed from diffusion processes in that the random mechanism was in the medium instead of the fluid. Practical examples of percolation processes were molecules penetrating a porous solid, or disease infecting a community. The processes could be studied in crystals or mazes, and the mathematics was more difficult than that of diffusion processes. It was possible to show rigorously that critical probabilities existed for crystals below which, for example, a fluid starting in one part of the medium would not spread to infinity. Upper and lower limits had been established theoretically for these probabilities, and Monte-Carlo methods had been successfully used to estimate them.

It was not surprising to find several papers devoted to the random walk problem and Brownian movement. Dr. P. H. Roberts (King's College, Newcastle) spoke on the "Random Walk on a Sphere". He was concerned with the geological problem of the path of the Pole as indicated by rocks. Other work in this field had assumed a lattice model, and a planar distribution[8a]. With the mathematical help of H. D. Ursell, he had used the correct distribution for a sphere, which, incidentally, differed appreciably from the distribution given by R. A. Fisher[8b].

The effect of persistence on a random walk was discussed by Mr. A. J. Allnut. In problems such as multiple scattering in foils the assumption that all directions of scatter were equally probable after collision was invalid; it was necessary to take into account persistence in the initial direction, and formulæ for the mean and mean square deviation could readily be derived. Mr. J. C. Barton (Northern Polytechnic, London) described an experimental method of simulating a one-dimensional random walk. This was a problem in which an analogue computer could be of value and could provide information on first passage times for a random walk with persistence[9]. (In the discussion Prof. Bartlett pointed out that theoretical formulæ for first passage times were available for all Markoff processes.)

Dr. A. R. Stokes (King's College, London) in his paper on "Light Scattering by Semi-stiff Chain Molecules" referred to a different application of an analogous problem. The distribution of the end-to-end distance of a flexible chain was Gaussian; stiffness in the chain restricted the freedom of the angle between successive links, and modified this distribution, thus influencing the light-scattering properties. The modified distribution had been calculated by Daniels[10], but he had found a simpler approach by using the Fourier transform of the end-to-end distance. The results could be expressed in a form suitable for practical calculation.

The Brownian movement of non-linear systems was discussed by Dr. D. K. C. MacDonald (National Research Council, Ottawa). Many problems in this field still awaited solution. Some results of his own approach[11] had been substantiated by R. O. Davies[12], although there was some disagreement with van Kampen[13], who maintained that the distribution of fluctuations was Gaussian even for non-linear systems. Dr. MacDonald mentioned that he had corresponded with Einstein, who agreed that the statement in his early work on the Gaussian nature of the distribution needed reconsideration.

Dr. A. Suddaby (Sir John Cass College, London) discussed the relation between the microscopic theories of transport processes developed by Kirkwood, and the macroscopic theory of Brownian movement. In the course of his development, Kirkwood introduced a friction constant β which was an integral up to time τ of the correlation of the total force on the particle at different times. The analogous constant in Brownian movement theory was determined by the correlation of the fluctuating force in the Langevin equation. These two values could be shown to agree provided $\beta\tau \ll 1$.

Dr. E. R. Wooding (University of Sheffield) presented a paper on "Recombination in a Plasma as a Stochastic Process". The rate at which ions of opposite charge diffused together was obtained by applying Kramer's method to solve Smoluchowski's equation for diffusion in a field of force. Charge transfer was assumed to occur after the ions approached to within a distance where they could enter a bounded orbit. An ion or atom in the vicinity of an orbit influenced the recombination coefficient. The resulting function was dependent on the degree of ionization, but was similar to that obtained by Thomson[14] at low pressures, and changed to Jaffe's relationship[15] at high pressures if the ionization was low.

Dr. G. Wyllie (University of Glasgow) discussed the Brownian motion of spin systems. There were two sources of interest in this problem, its neatness as a model for irreversible processes in quantum mechanics, and the experimental interest in nuclear magnetic resonance experiments. If one focused on individual spins, relaxation times were of the order of milliseconds, whereas for the whole spin system they ranged up to hours. By manipulating electromagnetic fields the spin system could be thrown into conditions far from the Boltzmann distribution. The fluctuating interaction between spins revealed itself in the shape of the magnetic resonance absorption line.

A group of papers was concerned with stochastic problems arising in radio physics. Mr. J. A. Ratcliffe (University of Cambridge) gave an introductory talk, and discussed some problems associated with the Fresnel diffraction patterns formed by an assembly of random irregular diffracting screens. It was well known that, if the correlation function $\rho_f(\xi)$ of the complex amplitude $f(x)$ over a one-dimensional diffracting screen was defined as $< f(x) f^*(x + \xi) >_{\text{screen}}$ and if $g(x)$ was the complex amplitude in the diffraction pattern over any plane parallel to the screen, then with certain reservations $\rho_f(\xi)$ was equal to $\rho_g(\xi)$. If the screen was statistically stationary over x and if the correlation function $r_f(\xi)$ was defined as $r_f(\xi) = < f(x_1) f^*(x_1 + \xi) >$ evaluated at two fixed points x_1 and $(x_1 + \xi)$, then it was also true that $r_g(\xi) = r_f(\xi) = \rho_f(\xi)$. If, however, the screen was not statistically stationary the last relation was not necessarily true.

Mr. Ratcliffe considered particularly the non-stationary case when the screen $f(x)$ could be described as an assembly of infinitely long random screens placed, in succession, in front of an aperture of finite width. He suggested that this simple example represented approximately the problems of the diffraction of (*a*) radio waves radiated from a radio star with a sharp boundary, (*b*) light waves radiated from a source of light placed behind a slit, or (*c*) radio waves reflected from an irregular meteor trail of limited length. He stated that, if the limiting aperture subtended less than the first Fresnel zone at the observing plane, then $r_g(\xi)$ was determined, not by the fine structure in the screen, but by the aperture bounding it. If, however, the aperture subtended a large number of Fresnel zones then $r_g(\xi) = r_f(\xi)$ and was determined by the fine structure in the screen.

Mr. S. A. Bowhill (Pennsylvania State University) discussed the scattering of electromagnetic waves from a continuous medium containing three-dimensional random inhomogeneities of refractive index. He had derived the form of the emerging angular power spectrum when the scales of the inhomogeneities were different in the three space directions. Contrary to previous results[16], he had found that the medium could not be analysed as a series of superposed thin phase screens, spaced in the propagation direction, and with independent phase profiles.

Mr. M. L. V. Pitteway (University of Cambridge) was concerned with reflexion from an irregular medium. Before proceeding to a three-dimensional solution for irregularities he thought one should obtain a solution for a horizontally stratified ionosphere[17] and treat the irregularities as a small perturbation. The power spectrum of the scattered wave could then be expressed as an integral in terms of the stratified solution. Dr. B. H. Briggs (University of Cambridge) dealt with the experimental problem of specifying the pattern on the ground (including time changes and movements) formed by reflexion from, or transmission through, an irregular ionosphere. He defined parameters which could be used to specify this pattern, and which could be deduced from observations at a few points on the ground[18]. As an example, he considered the application to radio star scintillations. Mr. R. P. Mercier (University of Cambridge) discussed theoretical aspects of radio-wave fading. A scalar wave with random variations of amplitude and phase across the wave front was taken as a simple model. It was assumed that the in-phase and quadrature components of the fluctuating part of the field were normally distributed, and a parameter was introduced to specify the intrinsic correlation of the fading. Various properties of this parameter could be derived, and used to interpret fading from the ionosphere.

"Coherence Properties of Partially Polarized Light" was the subject of the paper by Dr. E. Wolf (University of Manchester). Observing that the usual definition of Stokes parameters of a quasi-monochromatic plane electric wave was not unique, an experiment was analysed which led to a unique coherency matrix and to a unique set of Stokes parameters The degree of polarization of such a wave was also equal to the maximum value of the degree of coherence which existed between the components of electric vibrations in orthogonal directions in the wave front This suggested a new method of measurement of the degree of polarization, based on interference experiments

Prof E G Richardson (King's College, Newcastle) referred to experiments on the propagation of sound waves in a fluid having random variations in either density or momentum, whereby the amplitude and relative phase of the signal picked up after transmission through the medium fluctuated in time The former type occurred near the critical point of a fluid or of a mixture of liquids, the latter in the atmosphere or in the wake of an obstacle or, again, in a boundary layer Analyses of such measurements were presented In the case of the liquid mixture a correlation was sought between the pattern of the scattered radiation and the mean size of the clusters which formed at the critical point As an example of the second type, frequency spectra of the modulations of the sound signal transmitted athwart the wake of a cylinder involved the discerning of peaks in the spectrum against the background of fluctuation 'noise' in the general flow

Dr M S Longuet-Higgins (National Institute of Oceanography) discussed "Sea-Waves as a Stochastic Process" He showed a typical record of pressure at a fixed point on the sea bed which agreed closely with a Gaussian distribution Non-Gaussian features usually appeared when the waves were steep and near the point of breaking, or in shallow water. To describe the sea surface a random process two spatial dimensions and one of time were needed, the practical problem for wave forecasting was to relate this to winds and other relevant factors Dr Longuet-Higgins also listed a number of properties of a Gaussian surface which might be of use in determining the spectrum, these included wave slopes[19], 'specular points' and 'twinkles'[20]

The final paper was given by Prof E W Montroll (University of Maryland) on a stochastic treatment of traffic flow Experimental data indicated that the acceleration of a car in a line of traffic at time t was proportional to the velocity difference between itself and its neighbour at time $(t - \Delta)$, where $\Delta \sim 1\ 5$ sec and the proportionality constant[21] was 0 37 sec^{-1} Theoretical investigation showed that the motion became unstable when the product of lag time and proportionality constant exceeded 1/2 Thus the experimental data showed that driving was usually on the verge of instability 'Acceleration noise' was put forward as a parameter which would characterize the driver – car – road complex under various conditions[22] Reasonable agreement was obtained with traffic flow measurements[23]

The conference was organized at the suggestion of Dr Furth, who is to be highly commended on his initiative The one hundred participants would undoubtedly wish to express their thanks to him, to Birkbeck College, and to the Physical Society for the excellent arrangements

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[1] Hagfors, T , and Landmark, B , *Proc Inst Elec Eng* , B, **105**, 555 (1958)

[2] Rice, S O , *Bell Syst Tech J* , **23**, 282 (1944)

[3] Moore, M N , *Nuclear Science and Engineering*, **3**, 387 (1958).

[4] Broadbent, S R , and Hammersley, J M , *Proc Camb Phil Soc* , **53**, 629 (1957) Hammersley, J M , *ibid* , **53**, 642 (1957) , *Ann Math Statist* , **28**, 790 (1957)

[5] Hammersley, J M , and Morton, K W , *J Roy Stat Soc* , B, **16**, 23 (1954)

[6] Fisher, M E , *Farad Soc Disc* , **25**, 200 (1958)

[7] Wall, F. T , Hiller, L A , and Atchison, W F , *J Chem Phys* , **26**, 1742 (1957) Wall, F T , Rubin, R J , and Isaacson, L M , *J Chem Phys* , **27**, 186 (1957)

[8] Fisher, M E , and Sykes, M F , *Phys Rev* , **114**, 45 (1959) [8a] Green, R , *Nature*, **182**, 382 (1958) [8b] Fisher, R A , *Proc Roy Soc* , A, **217**, 295 (1953).

[9] Barton, J C , Campbell, D A , and Read, R C , *Proc Phys Soc* , A, **70**, 605 (1957)

[10] Daniels, H E , *Proc Roy Soc Edin* , **63**, 290 (1952)

[11] MacDonald, D K C , *Phys Rev* , **108**, 541 (1957)

[12] Davies, R O , *Physica*, **24**, 1055 (1958)

[13] Van Kampen, N G , *Phys Rev* , **110**, 320 (1958)

[14] Thomson, J J , *Phil Mag* , **47**, 337 (1924)

[15] Jaffe, G , *Phys Rev.*, **58**, 968 (1940)

[16] Fejer, J A , *Proc Roy Soc* , A, **220**, 445 (1953) Feinstein, J , *Trans Inst Rad Eng* , AP-2, **23**, 63 (1954) Bramley, E N , *Proc Roy Soc* , A, **225**, 515 (1954)

[17] Pitteway, M L V , *Proc Roy Soc* , A, **246**, 556 (1958)

[18] Briggs, B H , Phillips, G J , and Shinn, D H , *Proc Phys Soc* , B, **63**, 106 (1950) Phillips, G J , and Spencer, M , *ibid* , **68**, 481 (1955)

[19] Cox, C , and Munk, W , *J Opt Soc Amer* , **44**, 838 (1954)

[20] Longuet-Higgins, M S , *Phil Trans Roy Soc* A, **249**, 321 (1957) , **250**, 157 (1957) , *Proc Camb Phil Soc* , **55**, 91 (1959)

[21] Chandler, R E , Herman, R , and Montroll, E W , *Operations Res* , **6**, 165 (1958)

[22] Herman, R , Montroll, E W , Potts, R B., and Rothery, R W , *Operations Res.*, **7**, 86 (1959)

[23] Greenberg, H , *Operations Res* , **7**, 79 (1959).

BIOMECHANICS

ON April 17 the Institution of Mechanical Engineers held a symposium on "Biomechanics" with the purpose of bringing medical men and engineers into closer contact

Biomechanics, in its broadest sense, may be defined as the branch of science which applies the principles of mechanics and the techniques of engineering to the human body in the process of its repair, and in the field of man – machine relationship, where man is the essential link in operating these machines

The symposium was opened by the President of the Institution and the papers and discussion were presented under the chairmanship of Prof S J Davies In the opening paper on the importance of biomechanics as a service to man, illustrated by a discussion of problems in metallic osteosynthesis, J M Zarek, from King's College, London, gave a brief account of the nature of biomechanics as a new field of endeavour in which some of the engineering knowledge may be of direct use to the medical man The man – machine relationship was only mentioned, as this aspect of biomechanics appears to be already well appreciated by the engineers and was not dealt with at the symposium in detail After discussing the scope of biomechanics, the general history and current British activities in this field were reviewed Problems of bone repair were considered at length and the work in the Civil Engineering Department at King's College, London, on the stress/bone formation relationship and the behaviour of metals in the human body were discussed

In the second paper, R I Tanner, from the University of Manchester, presented a paper on some tests on 'Fluon' as a material for artificial animal joints in which results of artificial hip-joint friction and wear are given They are based on the results obtained by means of simple pendulum apparatus which provides a reasonable approximation to the walking motion of a normal person

A critical review of published work on the nature of lubrication in animal joints was given by John Charnley from the Department of Orthopædics at Manchester Further, some of the experiments which have been accepted in support of the theory of hydrodynamic lubrication have been repeated by him to show that the lubrication of animal joints is almost certainly a boundary phenomenon Charnley emphasized that the coefficient of friction of animal joints reaches a very low figure and surpasses in slipperiness any combination of sliding surfaces known to engineering

A paper on the provision of workable substitutes for missing or defective limbs was presented by D S McKenzie and Brig N A M Swettenham, from the Limb Fitting Centre, Ministry of Health, Roehampton

Limb fitting has been essentially a craft until quite recently, and many ideas current in the last century exist materially unchanged to-day This situation is now changing as a great deal of research work on artificial limbs with emphasis on fundamental studies is in progress Some of the problems here are very complex The prosthesis has to replace a human component but it does not necessarily follow that its mechanical design should copy that of the part it replaces Amputation often changes the pattern of muscular control and weight bearing The paper also described some of the features governing the construction of artificial limbs Each case has to be treated individually and *ad hoc* modifications have to be made to suit individual needs In a research field of this nature it is difficult to prove that a proposed change has merit, and evaluation techniques still require much development Some devices evoke general acceptance, but more often individual responses vary and the type of case for which the new idea is best suited must be discovered Only users can supply the final answer, but they cannot give up unlimited time to experimentation Objective testing is therefore necessary to eliminate obvious flaws and shorten user trials

Following the presentation of the papers, a film entitled "Late Results of Four Massive Internal Prosthesis" was shown by A C Bingold and W G France Here the authors gave an excellent picture of how, through the co-operation of surgeons with engineers, instead of amputation, limbs can be saved and restored to their normal use

The success of the symposium, I think, was reflected in the very interesting discussion which followed and well exceeded the time limit allocated for this purpose

The Institution was honoured by the presence of Sir Harry Platt, of the Royal College of Surgeons, who, in opening the discussion, stressed the importance of interdisciplinary work between the medical men and engineers He said that the symposium had clearly demonstrated that some of the surgical techniques now in use are so complex that it is impossible for one profession only to solve the problems involved

Dr F C Harper, of the Building Research Station, showed a film and some results obtained in the course of studying the forces exerted by the human foot in walking, the emphasis there being on the wear resistance of floor surfacing materials

Dr J D Moreland and Mr S J Thurlow, of the Road Research Laboratory, discussed their investigations into the problems connected with road crash injuries

Mr E H J Smyth, an orthopædic surgeon from the Southampton and Isle of Wight Hospital Groups, presented in a very interesting manner his views on the functional significance of the formation of trabeculæ in the neck of the femur

Finally, because of shortage of time, after a number of speakers discussed a variety of subjects of their own interest, the authors of the papers answered various points raised in the discussion very briefly

In conclusion, the large attendance and the discussion were an indication that the Institution of Mechanical Engineers had organized a successful symposium which from the 'mixed' audience indicated the growing affinity between engineering and medicine in the process of alleviating human suffering

The Institution of Mechanical Engineers will shortly publish the proceedings of the symposium, which will include the discussion and communications

J M ZAREK

INTERNATIONAL STARCH CONVENTION, 1959

THE ninth annual Starch Convention, which took place at the Cereal Research Station, Detmold, Germany, during April 21–23, was attended by 360 chemists from seventeen nations The papers which were read to the meeting were divided into four sessions, on research and analysis, starch manufacture, starch fractions and derivatives and on industrial applications

The opening address was delivered by T J Schoch (Argo, Illinois), whose theme was the application of modern methods of starch chemistry to characterizing its useful properties Waxy sorghum starch, which is comprised wholly of amylopectin, can be given some of the characteristic properties of corn starch by cross-linking the polysaccharide chains with phosphate, epichlorhydrin or fatty acid groups The amount of cross-linking agent required to achieve this result is only 1 part per 1,000 parts of starch Thus waxy starches, which normally give rise to fluid pastes, are deprived of this property and become 'short' Simultaneously their resistance to shear increases greatly Another result is that such starches lose the property of gelatinizing in water at a precise temperature, and instead show a gradual increase in solubility with rising temperature Cross-linking also results in a marked improvement of resistance to freeze-thaw cycles, which has important implications for the food industry

Improved freeze–thaw characteristics show as a lower rate of sedimentation after freezing, and better gloss and transparency of the paste

The new properties of amylopectin obtained by cross-linking can be explained by a greatly reduced rate of retrogradation and greater internal rigidity of the starch molecule The technique of cross-linking can be extended to dextrines, which are used as remoistening gums on envelope flaps and labels The deterioration of such gums on ageing has been shown to be due to retrogradation of the dextrine in the presence of small amounts of water By using the hydroxyethyl derivative of dextrines for gumming purposes, the ageing characteristics of flap gums can be largely avoided Finally, Dr Schoch explained how starch films, which have been laid down by slow evaporation of water, have a greatly increased resistance to water when compared to quickly dried films This again can be shown to be due to retrogradation taking place during the slow drying of films

Prof M Samec (Ljubljana, Yugoslavia) described how the bursting and tear strength of paper can be markedly improved by using a starch size which has been previously irradiated with cobalt-60 This process might become of great importance if the cost of the radioactive material would be reduced in the future

The use of starch as sizing agent in the paper industry was described by J Seaman (Slough, Bucks) A beater size should preferably be a potato starch soluble in cold water, of which 5 per cent w/w is added to the paper pulp Such starches are manufactured by passing a slurry containing starch and borax over steam-heated drying rolls The product when re-dissolved has *p*H 8 5 at 5 per cent concentration For surface sizing it is advantageous to use an oxidized starch, which is manufactured by treating potato starch with sodium hypochlorite The material has to be cooked with water before use to give a size having *p*H 7 5 at 15 per cent solid-content For paper coating, white potato dextrine (1 part) is added to china clay (5–6 parts) and the mixture made up with water to a slurry having a solid content of 50 per cent

When selecting dextrines for coating purposes, it is essential to choose one with a maximum rate of set back to enable the coating to set on the surface of the paper as rapidly as possible

Prof M Mautner (Zagreb, Yugoslavia) described a new method for the continuous production of glucose by the acid hydrolysis of starch The starch slurry is first treated with hydrochloric acid and is then passed into a conical chamber, which rotates very quickly about its long axis The chamber is heated externally by steam and is provided with an inlet at the wide end and an outlet at its apex Ungelatinized starch particles are forced by centrifugal force to the walls of the chamber, where they gelatinize instantly In so doing their specific gravity is reduced and they are replaced by further ungelatinized granules The chamber has a peripheral speed of 30 m /sec and it can deal with 2½ tons of raw starch per hr After leaving the chamber the starch paste is fed into a series of flat, box-like heat exchangers, where the final conversion of starch to glucose takes place It is estimated that the total time required for conversion is only 18 min

At the Convention a total of twenty-two papers was read and they will be reprinted in full in the journal *Die Starke*

The actual Convention was followed during April 24–25 by the first meeting of the International Standards Organization Technical Committee No 93, which has been set up to establish international recommendations for analysis of starch, including its derivatives and by-products There were 65 delegates present from Czechoslovakia, Denmark, Eire, Finland, France, Germany, Hungary, Italy, India, The Netherlands, Norway, Switzerland and the United Kingdom The chair was taken by Prof K Heyns (Hamburg), the secretariat being held by the German Standards Association The British side of the work is in the hands of the British Standards Institute Committee on Analysis and Testing of Starch Products , ten members of this committee—representing manufacturers and users of starch and associated products, research interests and Government departments—were present The work already done by the British Standards Institute Committee enabled the British delegation to give a strong lead at these inaugural discussions of the International Standards Organization and many of the United Kingdom proposals were adopted

It was agreed that the scope of the new International Standards Organization committee should cover terminology, methods of sampling, methods of analysis and examination of starch, its derivatives (including hydrolysis products and dextrines) and its by-products

E Dux

THE EDUCATION OF TECHNOLOGISTS

THE presidential address to the Institution of Metallurgists, delivered by Prof A J Murphy on May 12, covered a field involving not only the metallurgist but also the technologist in general, and in no small measure the pure scientist as well

After dealing with matters of a more or less domestic nature, Prof Murphy turned his attention to the general background desirable in the training of the technologist From this the following has been extracted

Sooner or later in any discussion on the education of scientists and technologists the remark will be made "What a pity it is that you cannot give your bright young technical men some sense of cultural values" Often this can be recognized as the defensive manœuvre of a dyed-in-the-wool classicist, who, in an age of automation, atomic energy and satellites sighs for the day when he could with impunity, and publicly, dismiss science as something they used to call "stinks" at school

But there is more in it than that It must be admitted that far too many technically competent men are distressingly inept in communication by speech and writing This is very regrettable The blame rests primarily on the schools—of that I do not have the slightest doubt I do not believe that any reasonably intelligent boy who had been properly taught the elements of English grammar and syntax could perpetrate the mangled compositions which one encounters alike in Ph.D. theses and the scripts of technical representatives. As for some of the efforts at reported speech which one receives from secretaries of technical committees, one can only regret that the writers have not been able to experience the intellectual satisfaction to be gained from a proper appreciation of the sequence of tenses. The Institution of Metallurgists is trying to do something toward remedying this state of affairs by requiring the demonstration of at least a modest competence in the use of the English language as part of the qualification of a metallurgist. We must hope that by gradual seepage down the line this measure will encourage the schools to increase their efforts in teaching English for use.

We are all fully persuaded that premature and immoderate specialization can produce monsters. Once such damage has been done there is not much hope for rescue operations conducted in university faculties of science and engineering or in technical colleges. Again I think we must look to the schools for salvation. An awareness of what goes on outside his specialization ought to have been gained in the technologist's school days. Special lectures of one hour a week in the liberal arts, isolated from the technological course, make no appreciable impression on deficiencies in this respect which the student has brought with him to the university or technical college.

Somehow time must be found, or regained, in the schools for these opportunities to taste the many savours which go to make a full life. The late Prof. Samuel Alexander said that liberality was the "spirit of pursuit, not a choice of subject". Sir Eric Ashby, in a series of stimulating papers, and lately in his book "Technology and the Academics", has denied that technology and culture are antitheses, and has urged that technology properly taught can provide a path to culture through a man's specialization and not by by-passing it. In this respect technology has the advantage over pure science in its opportunities for developing cultural appreciation, since applied science necessitates contact with one's fellow-men outside one's specialization. If the technologist is to achieve the successful application of his science he must study his fellow man in order to understand his desires, his fears and his needs.

To the man whose training has been along the route of an apprenticeship and a Higher National Certificate qualification, corporate membership of a professional institution opens a door to promotion to positions of major responsibility which otherwise would remain closed. Much could be written about our neglect, during the thirty years or so before and after the beginning of the century, to appreciate the immensely valuable national asset which we possessed in this type of man, and we may yet have cause to regret our improvidence. Apprenticeship in the engineering and metallurgical industries fell into sad disrepute in those days. Less and less did it serve as a springboard for advancement to executive appointments save for men of exceptional ability, whom no system, however bad, could have held back; more and more it became merely a procedure for instilling into the youngster the minimum technical knowledge which operative employment required. In our time we see a new approach. Positive action is taken to encourage and help the young man in industry to broaden his educational horizon and to aim at the most ambitious target which his intellectual ability brings within his scope.

It is a good thing from time to time to count one's blessings. It adds zest to the enjoyment of good times and it helps to keep one's sense of proportion when things are not going so well. Sometimes a piece of good fortune is too obvious to be overlooked. There are also those blessings which become evident only after a little reflexion. In this category comes the privilege which we enjoy in a calling in the absorbing world of science and technology. It is indeed a happy circumstance for us that we make our livings by engaging in an occupation which commands our great interest, even apart from the tangible rewards which economic necessity compels us to exact. When we contemplate the lot of many of our fellow-citizens who must earn their daily bread by the performance of ineffably dull chores, then surely we cannot deny the boon with which by contrast we are favoured.

VISUAL ILLUSTRATION OF UNIVERSITY LECTURES

AT the annual general meeting of the British Universities Film Council, held at University College, Cardiff, on May 8 and 9, one session was devoted to a discussion, under the chairmanship of Prof. G. E. H. Foxon, on the problems of illustrating university lectures by film and related techniques. It was attended by several guests as well as the representatives of the universities on the Council.

Opening the discussion, the guest lecturer, Mr. C. E. Engel, of the Department of Medical Illustration, Guy's Hospital Medical School, and editor of *Medical and Biological Illustration*, took as his subject "The Lecture Theatre of the Future". He pointed out that considerable information was now available on several matters influencing design of lecture theatres, including the visibility of blackboards and of projection screens of different materials. The value of the 'recessed' type of screen was particularly stressed as it allows of sufficient illumination in the theatre for note-taking without impairing the quality of the projected image. Methods involving complicated arrangements of projection are usually considered unsuitable for university use because they upset the speed of the lecture and come between the lecturer and his audience by interposing another person as projectionist. Several devices to overcome this trouble were demonstrated, including: first, a projector for 2 in. × 2 in. slides with automatic slide change and change of focus; and secondly, the prototype of a magazine loading projector for loop films. The details of operation of this loop projector were demonstrated in close-up by closed-circuit television (with apparatus kindly lent by the Marconi Wireless and Telegraph Company), thereby showing another method of lecture illustration. Mr. Engel concluded by pointing out the need for a magazine-loading cine-projector operated by the lecturer by remote control so that the film sequence could be introduced precisely when required and, if necessary, repeated

Mr C J Duncan (University of Durham, King's College, Newcastle upon Tyne) said that the normal 'instructional film' with its elaborate production, titling and sound commentary was quite unsuited to the university lecture , what is required is a short piece of film which illustrates only the essential event in which the movement being dealt with occurs As an example, Mr Duncan demonstrated how, in describing a piece of apparatus, its components could all be shown by slides, thus enabling the speed of explanation to be varied on different occasions and the moving sequence showing the apparatus in use could be projected at the appropriate moment This method is of value in that it avoids the necessity of producing a complete film with all the necessary editing and titling, and so is much less expensive than an instructional film , also it is much more flexible and any subsequent modification of the apparatus or technique being demonstrated merely necessitates the substitution of a small piece of film and not the production of a completely new full-length film These short films lasting some 15–20 sec can be called 'moving diapositives', and if several are joined together by short lengths of blank film, during which the projector is stopped, several such short sequences can be shown in one lecture without re-threading the projector and thus disturbing the lecture

Prof H I Stonehill (Royal Military College of Science, Shrivenham) reviewed the use of television as a medium of instruction at college- and university-level in the United States, emphasizing how much this method was being employed there for instruction at all levels In discussing in more detail its use in universities an account of some assessments of its value was given , apparently, results so far indicate that students 'attending' lectures by television do as well in tests as those actually present in the lecture room Some students were reported to prefer television lectures because, when concentrating on the screen, they had less difficulty in preventing their attention from wandering than when in a large audience

Mr A M P Brookes (Cambridge) described experiments now going on in the Engineering Laboratories at Cambridge where, on account of large numbers, some students were 'attending' the lectures in an adjacent room to which the lecture was televised The lectures involved were those given by Mr Brookes himself, and he told of the first attempt and the modifications in technique that had been made in succeeding lectures Small television cameras can be set up in the lecture room without waste of space, so sited that they cover the movements of the lecturer and show the blackboards clearly It is important that the lecturer should appear in the picture in reasonable proportion when seen against the blackboard , close-ups which tend to turn the lecturer into a 'television personality' are to be avoided The necessity for keeping in view of the television cameras does tend somewhat to limit the movement of the lecturer on his rostrum It is of great importance that the camera covering any one blackboard remains in use long enough for students to copy any diagram or note which it is expected they shall copy At present, Mr Brookes and his colleagues are learning by trial and error, but inspection of students' note-books indicates that those receiving the lecture by television make as full notes as those in the lecture-room

During a general discussion which followed, Mr Brookes, with the aid of the equipment present, gave a demonstration of 'blackboard work' by television

This session covered a wide field, and while little summary is possible, attention may be directed to the point made by several speakers that films and television are so well adapted to mass instruction that their possible uses at university-level tend to be overlooked This is particularly so with films, for although instructional films have been available for many years, suitable film illustration for a university lecture is hard to come by This, as has already been suggested, is because instructional films are produced as complete entities There is a need for the provision of short lengths of film illustrating those particular points, which are found in several sciences, when movement plays such an essential part that it cannot be illustrated by other means Whether this can be done on a commercial basis or whether such sequences, perhaps produced in the course of research, can be exchanged between university departments remains to be seen

G E H FOXON

THE HALDEN (NORWAY) REACTOR

THE boiling heavy-water reactor of the Norwegian Institutt for Atomenergi at Halden, which is to be used for a joint programme of research and experiment organized by the Organization for European Economic Co-operation, European Nuclear Energy Agency, was successfully operated for the first time on June 29, 1959 The reactor, moderated and cooled with heavy water and fuelled with natural uranium, is located in an excavation in a rock near the paper and pulp factory Saugbrugsforeningen in Halden, 120 km south of Oslo It is the first boiling heavy-water reactor in the world, and the first boiling-water reactor in Europe Besides its main function as a power demonstration reactor for studying problems associated with boiling heavy-water reactor systems, the installation will also produce some 15 tons per hour of process steam in the secondary light-water circuit Eventually this steam will be used in the paper factory and it is believed that this will be the first nuclear process steam installation

The reactor was designed at the Netherlands–Norwegian Joint Establishment for Nuclear Energy Research, Kjeller, and was built by the Norwegian Institutt for Atomenergi The main sub-contractors were the Kvaerner-Myhren, -Thune Combine (mechanical installations), the Chr Michelsens Institutt (control and instrumentation), Høyer Ellefsen (civil engineering work), the U K Atomic Energy Authority (fuel), and the U S Atomic Energy Commission (heavy water) The total cost of the plant, including heavy water and the first uranium fuel load, was 3 5 million dollars

The Organization for European Economic Co-operation Agreement concerning the reactor was signed in June 1958 by Austria, Denmark, Euratom (representing Belgium, France, Germany, Italy, Luxembourg and the Netherlands), Norway, Sweden, Switzerland and the United Kingdom It provides for a joint programme, budget and staff for research and development work with the reactor for a period of three years Through agreements with the Institutt for Atomenergi, the United States and Finland are also associated with the reactor project At present, a professional staff of thirty, recruited from the participating countries, is attached to the project During the next six months the reactor will be operated at low power-levels to enable fundamental reactor physics experiments to be performed After this period the power level will be increased gradually up to the design power of 10 MW thermal energy

The reactor plant will be officially opened by H M King Olav on October 10

The Halden Reactor Project is one of several joint undertakings sponsored by the European Nuclear Energy Agency of the Organization for European Economic Co-operation , others are the 'Eurochemie' company for the chemical processing of irradiated fuels (established by an international convention signed in December 1957) and the *Dragon* high-temperature gas-cooled reactor project, work on which began last April

THE DANISH ATOMIC ENERGY COMMISSION

THE report on the activities of the Danish Atomic Energy Commission* for the period April 1, 1957, to March 31, 1958, deals mainly with the erection of the Risø Research Establishment and the three reactors *DR*1, *DR*2 and *DR*3, and the work of the six departments of the Establishment The membership of the Commission remained unchanged during the period under review, and Prof Niels Bohr continued to act as chairman The total cost of the Establishment was originally estimated at about 100 million kroner The expenditure so far, including that estimated for 1958–59, is about 90 million kroner, of which about 60 million kroner is for expenditure on buildings and the remainder for the three reactors and the requisite technical and scientific equipment On March 26, 1958, the Finance Committee authorized an additional expenditure of up to 2 5 million kroner on a linear accelerator to be used for experiments on the preservation of food and for other irradiation experiments

On August 15, 1957, the first of the three reactors began to operate, and by September the chemical, reactor engineering, electronics and physics laboratories together with the administration building were completed and in use Then followed the health physics department, the library and the canteen, and early in 1958 the agricultural department, the lecture hall and the buildings to house the *DR*2 reactor group were completed, leaving only the buildings for the *DR*3 reactor to be erected A detailed map attached to the report shows the complete layout of the Establishment

In the physics department one group has been working on the construction of a laboratory for investigations of beta- and gamma-ray activities , another group with neutron spectroscopy , and a third group with solid state physics, particularly the study of the effects of radiation damage to metals and graphite A study has also been made of the literature on deuterium fusion and of the theoretical aspects of the utilization of the energy from deuterium fusion The electronics department has undertaken active research on scintillation counters and on the development of a reactor simulator Two study groups were formed in the reactor engineering department The first was engaged in drafting a project for a heavy-water-moderated power reactor with an organic cooling medium, and the second for a high-temperature gas-cooled reactor

A section of the report is devoted to the International Atomic Energy Agency, and to regional co-operation in Europe, including the Organization for European Economic Co-operation and Euratom The report also gives details of geological surveys in Greenland , relations between the Commission and commerce and industry , educational activities which included experimental reactor courses with *DR*1 and lecture courses at the Technical University of Denmark , and general information services

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* Report on the Activities of the Danish Atomic Energy Commission for the period from 1 April 1957 to 31 March 1958 Pp 62 (Copenhagen Danish Atomic Energy Commission, 1958)

ATOMIC POWER CONSTRUCTIONS, LTD.

ATOMIC POWER CONSTRUCTIONS, LTD , 28 Theobalds Road, London, W C 1, which was formed in December 1956, is carrying out extensive research and development in connexion with the national nuclear power effort The research programme is concentrated at the company's laboratories at Heston, Middlesex, and a booklet* recently prepared gives a survey of the problems being tackled In the Calder Hall type of reactor the uranium is arranged in a pattern of vertical rods embedded in a large cylindrical 'core' of graphite The heat generated in the rods is carried away by blowing carbon dioxide gas past them, and in order to economize in pumping power the reactor designer puts the whole of the carbon dioxide gas circuit under a pressure of some 20 atmospheres Consequently, the core and uranium must be enclosed in a pressure vessel

Most stringent precautions must be taken against failure of the pressure circuit in which the carbon dioxide circulates, and a major part of the work undertaken by Atomic Power Constructions, Ltd , is concerned with proving the materials and fabrication techniques which are used in the construction of the pressure vessel An important problem is creep of the steel to be used for the pressure vessel and for the heat exchangers, and in order to acquire the necessary information sufficiently quickly an air-conditioned creep laboratory containing a battery of seventy creep machines has been set up The strain ageing of steels at elevated temperatures , weldability and welding techniques for use with selected steels, and the chemical compatibility of the various materials used in the reactor with the carbon dioxide coolant gas, are some of the other problems being investigated by the Metallurgical Division A considerable expansion in facilities is planned during 1959, and additional long-term researches relating to uranium, magnesium and the weldability of steel will be started The design of the best heat transfer surface for the fuel elements is at present largely empirical and at the Heston Research Laboratories two experimental rigs are provided for experimental tests In both, the fuel element can is placed in a working section and the heat developed in the uranium simulated by an electric heater Facilities for basic studies in heat transfer and in other design problems have also been set up, and these facilities comprise a flow visualization rig and associated equipment in which water replaces the pressurized carbon dioxide as the working fluid

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* Research and Development at the Heston Laboratories of Atomic Power Constructions, Limited Pp 10 (London Atomic Power Constructions, Ltd , 1959)

Crompton Parkinson, Ltd, the Fairey Aviation Co, Ltd, International Combustion (Holdings), Ltd, Richardsons Westgarth and Co, Ltd, and Nuclear Civil Constructors (Trollope and Colls, Holland and Hannen, and Cubitts) form the five member companies of Atomic Power Constructions, Ltd

COFFEE RESEARCH IN THE BELGIAN CONGO

TWO investigations of a fundamental character on the genus *Coffea* have recently been published by the Institut National pour l'Étude Agronomique du Congo Belge, (i) Recherches sur l'Autostérilité du Caféier Robusta (*Coffea canephora* Pierre) by M Devreux, G Vallaeys, P Pochet and A Gilles (No 78 1959 Pp 44+8 plates 40 francs), (ii) Recherches sur les Affinités Chromosomiques dans le Genre *Coffea* by J Bouharmont (No 77 Pp 94+2 plates 70 francs) The self-sterility of Robusta coffee has been known in a somewhat confused way for many years, but no convincing demonstration of this phenomenon has previously been presented This information is important in preparing a rational programme of selection The investigators of the work indicated above have now shown, under strictly experimental conditions, that this variety is quite self-sterile As a result of many controlled self-pollination experiments, using 19 clones and based on a very large number of flowers, for example, more than 15,000 in one instance, an extremely small number of fruits has been obtained, the highest percentage not exceeding 0 24 By contrast, when the flowers of the same clones were subjected to cross-pollination, a number of ripe fruits, 30–40 per cent, was obtained The self-sterility is not attributed to defects in floral structure or in micro- or macrosporogenesis but to anomalies in the formation and growth of the pollen-tubes In no case were these able to traverse the style While a genetical explanation in terms of incompatibility may be advanced, validation has still to be obtained

Observations on the chromosome numbers of thirteen species of *Coffea*, including all the well-known species such as *C arabica*, *C liberica*, *C stenophylla*, etc, have shown that all those examined are diploid with 22 chromosomes, except *C arabica* which has 44 Certain hybrids are diploid and others tetraploid The nuclear behaviour at mitosis is apparently identical in all the species Measurements of chromosome lengths show that these are all much alike It is considered that these comparisons by measurement confirm the close systematic relation of certain species, but it does not enable a general classification of the genus to be established An average idiogramme of the African *Coffea* has been prepared The author concludes that the genus is a very homogeneous one, and that the species investigated are closely related from the cytological point of view Lastly, this investigation has yielded no evidence of difficulties in obtaining interspecific hybrids

BOTANY IN SCOTLAND

AN agreeable and very well-deserved tribute has been paid to Prof J R Matthews, regius professor of botany in the University of Aberdeen, by his friends, past and present colleagues and former students, on the occasion of his seventieth birthday During his twenty-five years as regius professor he has greatly increased the stature of his Department, has helped the cause of botanical science by his work on the councils of various societies and has made many valuable contributions to botany, especially in the field of research relating to the origin and distribution of the British flora The presentation volume under consideration has been printed for the Botanical Society of Edinburgh and appears as a special number of the *Transactions* (38, March 1959 15*s*) There is a foreword by H R Fletcher, and, as might perhaps be expected, a number of the articles relate to the ecology of Scottish plants But there are also some contributions dealing with other aspects of botanical science, for example, "Some Fundamental Considerations on the New Morphology", by H J Lam, "Peristome Teeth and Spore Discharge in Mosses", by C T Ingold, a biographical essay on "The Rev John Walker (1731–1804)—a Notable Scottish Naturalist", by G Taylor, of the Royal Botanic Gardens, Kew, and J Grant Roger has contributed a useful article on the "Conservation of the Scottish Flora"

Further evidence of the work of this distinguished and active botanical society has also been published (*Trans*, 37, Part 4, 1959) This is devoted entirely to various aspects of Scottish botany Thus there are floristic studies of a number of different regions, sometimes combined with geological observations D Ratcliffe has contributed an article on the "Habitat of *Koenigia islandica*", and D G Downie on "*Rhizoctonia solani* and Orchid Seed" There is a special cryptogamic section by D M Henderson and an alpine section by D Grant Roger There is also a useful general article dealing with botanical research in Scotland This gives a brief account of the activities of the main research institutes, including those devoted to marine biology and nature conservancy, but it is not concerned with university departments of botany

HABIT OF ICE CRYSTALS GROWN IN HYDROGEN, CARBON DIOXIDE AND AIR AT REDUCED PRESSURE

By A. P. van den HEUVEL and Dr. B. J. MASON
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ICE crystals grown from the vapour in air at normal atmospheric pressure show a remarkable variation of crystal habit with temperature. This has been closely investigated by Hallett and Mason[1] by growing crystals on a thin fibre running vertically through the centre of a diffusion cloud chamber in which the vertical gradients of temperature and supersaturation were accurately controlled and measured. The results of many experiments covering a temperature range of 0° to −50° C and supersaturations varying from a few per cent to about 300 per cent (in very clean, droplet-free air) consistently showed the crystal habit to vary along the length of the fibre in the following manner: 0° to −3° C, thin hexagonal plates; −3° to −5° C, needles; −5° to −8° C, hollow prisms; −8° to −12° C, hexagonal plates; −12° to −16° C, dendritic stellar crystals; −16° to −25° C, hexagonal plates; −25° to −50° C, hollow prisms. These changes of habit were controlled almost entirely by the temperature, the supersaturation influencing only such secondary features as the growth-rate and the onset of dendritic and needle growth. Similar conclusions have been reached by Kobayashi[2].

In attempting to account for these changes of habit, considerable interest is attached to recent reports by Isono *et al.*[3,4] that they are further modified if the crystals are grown in an atmosphere of hydrogen instead of air, but that little change is effected by replacing air with carbon dioxide. In particular, Isono found that crystals grown in a water-saturated air at −7° C developed preferentially along the *c* axis to form hexagonal prismatic columns; but, in hydrogen, the growth-rates in the *a* and *c* directions were approximately equal. Furthermore, needle-like crystals grown in air thickened, and skeletal growth was suppressed when the air was replaced by hydrogen. Crystals grown at −16° C in air took the form of thin hexagonal plates, but those grown in otherwise similar conditions in hydrogen developed as thick plates and short hexagonal columns.

In general, the effect of hydrogen was to produce more nearly isotropic growth and isometric crystals, changes which were attributed to the high diffusion coefficient of water vapour in hydrogen, it being 3.4 times that in air. The fact that crystals grown in carbon dioxide were very similar to those grown in air at the same pressure was taken to be consistent with the diffusivity being only 0.7 times that in air.

If the rate of diffusion of water vapour were an important factor in controlling crystal habit, very similar results to those obtained in hydrogen should be obtained in air at reduced pressure since the diffusivity is inversely proportional to the air pressure. Indeed, Kobayashi[2] and Isono[4] report that reduction of the air pressure does influence the shapes of crystals grown in both diffusion- and mixing-cloud chambers.

Isono found that his results obtained at −7° and −16° C in hydrogen were reproduced in air at pressures of 80–20 mm mercury. Kobayashi reports that the hexagonal plates and dendritic crystals found at temperatures between −10° C and −20° C in air at normal atmospheric pressure persist if the pressure exceeds 300 mm., but, at less than 100 mm. pressure, they are entirely replaced by hexagonal columns, often with hollow cavities, and, at less than 70 mm. pressure, by short solid columns which now occur at all temperatures between 0° C and −30° C. Unfortunately, under the conditions of the experiment, the total pressure could not be lowered without also lowering the supersaturation of the vapour, and Kobayashi attributes the formation of solid prismatic columns at low air pressures to the slow growth conditioned by the low supersaturation. He supports this view by recording that in air at normal atmospheric pressure only solid columns are obtained in

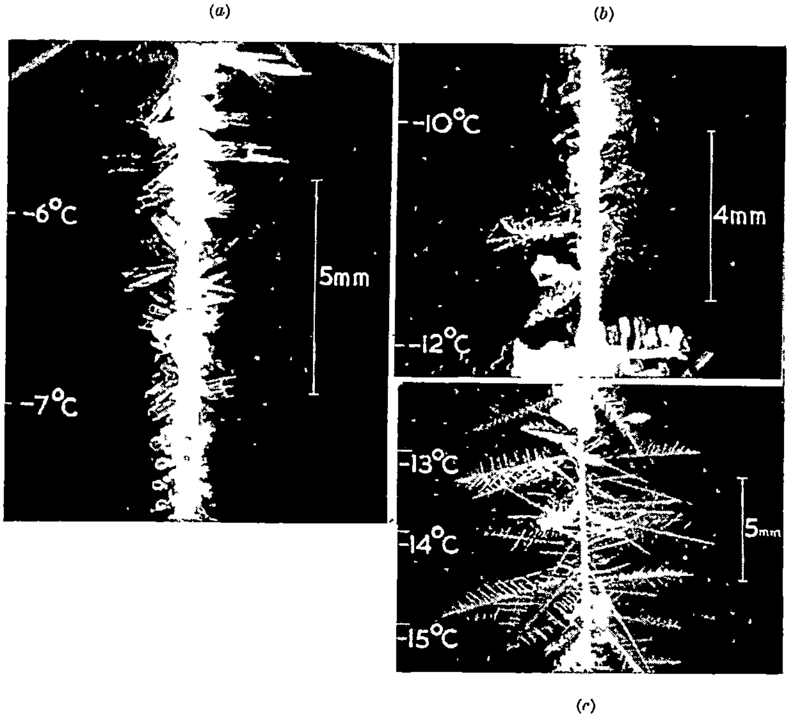

Fig. 1. Ice crystals growing in an atmosphere of hydrogen on a fibre suspended in a diffusion cloud chamber

a, Needles and hollow prisms in the temperature range −5° to −7.5° C; *b*, plates between −9° and −12° C; *c*, dendrites between −12° and −16° C

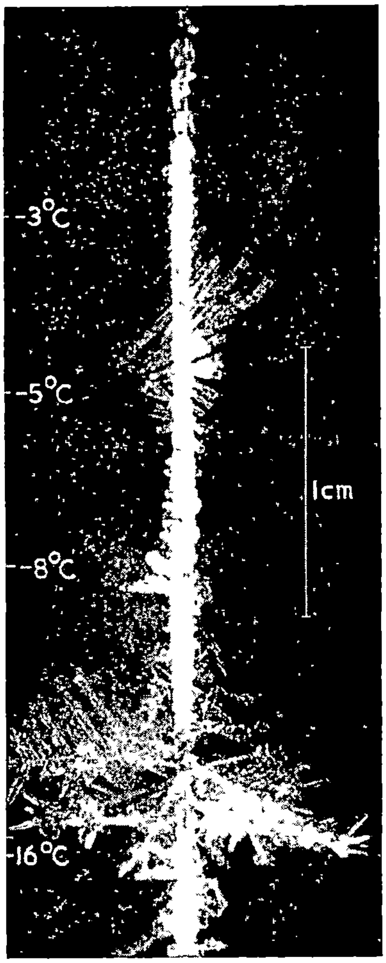

Fig. 2. Crystals grown in air at 80 mm. mercury pressure. The sequence is plates → needles → hollow prisms → plates → dendrites → plates as the temperature varies from 0° to −20° C.

the temperature range 0° to −30° C. providing the supersaturation does not exceed 7 per cent with respect to ice.

Because the results of these Japanese experiments in hydrogen and in air at low pressure, if confirmed, might throw new light on the mechanism responsible for the remarkable habit changes in ice, similar investigations have been made by us.

The crystals were grown, in aerosol-free air, in the diffusion cloud chamber described by Hallett and Mason[1]. They were supported on a fine fibre along which the temperature varied from 0° to −50° C. and the supersaturation could be varied and measured over a wide range. In a chamber filled with hydrogen at atmospheric pressure, the crystals exhibited the same variation with temperature as listed above for crystals grown in air (Fig. 1). No differences were observed except that the crystals grew much faster in hydrogen, in conformity with the diffusion coefficient of water vapour being 3·4 times that in air, and the thermal conductivity, which controls the rate of dissipation of the latent heat of crystallization, being about seven times greater.

Crystals were also grown under reduced air pressures of 300, 150, 80, 40 and 20 mm. mercury, the pressure never varying by more than 1–2 mm. during the course of any one experiment. Again, as shown in Fig. 2, the habit varied with temperature in a manner identical to that observed at normal atmospheric pressure and dendritic forms could always be produced between 0° C. and −3° C., and also between −12° and −16° C., at high supersaturations.

Crystals were grown under low supersaturations at atmospheric pressure between two parallel sheets of ice maintained at slightly different temperatures. This arrangement allowed the temperature and supersaturation to be accurately determined. Under supersaturations not exceeding 5 per cent with respect to ice, plate and sector-plate crystals appeared in the temperature range −10° to −15° C. and therefore the experiments provided no support for Kobayashi's claim that only solid prismatic columns occur at all temperatures between 0° C. and −30° C. at such low supersaturations.

Summarizing, we have been unable to confirm that the habit of ice crystals grown from the vapour is essentially modified by growing them in either hydrogen or in air at reduced pressure, although their growth-rates are affected in the sense one would expect from the manner in which the diffusivity and thermal conductivity of the environment would influence the fluxes of water vapour and heat.

We are unable to offer an explanation of the results obtained by the Japanese workers except to suggest that, perhaps, their apparatus may have been contaminated with small traces of foreign vapours such as are known[5] to affect markedly the ice-crystal habit even though present in only very small quantities.

[1] Hallett, J., and Mason, B. J., *Proc. Roy. Soc.*, A, **247**, 440 (1958).
[2] Kobayashi, T., *J. Met. Soc. Japan*, **36**, 193 (1958).
[3] Isono, K., Komabayashi, M., and Ono, A., *Met. Papers Geophys. Inst. Tokyo Univ.*, **8**, 327 (1958).
[4] Isono, K., *Nature*, **182**, 1221 (1958).
[5] Hallett, J., and Mason, B. J., *Nature*, **181**, 467 (1958).

CELL-WALL MUCOPEPTIDES OF *STAPHYLOCOCCUS AUREUS* AND *MICROCOCCUS LYSODEIKTICUS*

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A CONSIDERABLE number of recent studies have been concerned with the superficial layers of micro-organisms. In particular, insoluble material which is resistant to the action of several proteolytic enzymes and nucleases has been isolated. The morphology of this material is such that it may be regarded as consisting of the cell walls. Lysozyme-sensitive micro-organisms yield walls which are dissolved by lysozyme. In Gram-positive species the material has a relatively simple overall chemical composition compared with that of the cytoplasmic proteins, and its biosynthesis is inhibited by antibiotics such as penicillin and bacitracin. Elucidation of the more detailed chemistry of the structure and biosynthesis of the cell wall holds, therefore, the hope of a further understanding of the mode of action of antibiotics The purpose of the present article is to discuss some recent observations made in these laboratories and elsewhere in relation to concepts about the structure and biosynthesis of the cell walls of, in particular, staphylococci and micrococci

The work of Salton[1] and Cummins and Harris[2] firmly established that a large proportion of the substance of cell walls of representative strains of several species of Gram-positive cocci, other than some streptococci, consists of a limited number of amino-acids, two amino-sugars and sometimes one or two hexoses, these component substances were detected on paper chromatograms of acid hydrolysates of the wall structures The name mucopeptide[3] has more recently been proposed to describe the group of polymeric substances containing these compounds The earlier work was not designed to give an exact indication of the quantitative interrelationship between the components or to express any attitude towards the number of polymers combined to give the final insoluble wall structure Suggestions of possible heterogeneity at the polymer-level were, however, contained in the earlier work of Mitchell and Moyle[4], who had isolated from a cell fraction they called "cell envelopes", polyol phosphate compounds Cell walls prepared by the Salton and Horne[5] method were known to contain small amounts of phosphorus, and later Baddiley[6] and his colleagues first obtained substances which they called teichoic acids from *Lactobacillus arabinosus* One component of teichoic acid associated with the wall structure was polyribitol phosphate carrying in covalent linkage either glucose or N-acetylglucosamine to which, in turn, alanine was bound in ester linkage This type of substance was shown to be present in cocci[6] Its amount varied from negligible quantities in walls from *Micrococcus lysodeikticus* to about 30 per cent in the strain of staphylococcus wall examined, these quantities were deduced from the phosphorus contents of the walls—only a small proportion of the calculated material is recorded as having been isolated Mitchell and Moyle[7] have recently shown that their polyol phosphate also contains ribitol phosphate The presence of substances of this type which can be extracted by cold trichloroacetic acid may explain the report[8] of the presence of components soluble in trichloroacetic acid and in water in frozen dried wall preparations

The homogeneity or heterogeneity of the structure remaining (that is, the mucopeptides) after the removal of teichoic acid is still unjudged Examination of the concentration of amino-acids in the mucopeptides from various strains of staphylococci and micrococci shows that considerable differences in the molecular proportions occur Moreover, the ratios for most of the strains do not fit any simple pattern Even if the small amounts of alanine present in the teichoic acid in walls from some strains cause some distortion of the values for the concentration of this amino-acid in the mucopeptide, such considerations do not apply to the other amino-acids Park and Strominger[9] have suggested that a uridine–muramic acid peptide originally isolated by Park[10] from penicillin-treated staphylococci may be a biosynthetic precursor of mucopeptide This peptide had its amino-acids (alanine, glutamate and lysine) in simple molecular proportion and resembled in this respect the wall mucopeptide If this compound should eventually prove to be a precursor, then presumably other precursor compounds corresponding to the glycine and glucosamine present in the wall must be found The molecular ratios for the amino-acids in other strains of staphylococci or micrococci such as 11, 524 or *lysodeikticus* are not simple and the condensation of a single small peptide could not account for them If, however, there is more than one mucopeptide in the wall and possibly a multiplicity of uridine peptide precursors, as has been suggested by Ito, Ishimoto and Saito[11], then this situation is more easily explained

Table 1 AMINO-ACID COMPOSITION OF CELL WALLS EXPRESSED AS MOLAR RATIOS (GLUTAMATE TAKEN AS 1.0) IN SEVERAL STRAINS OF STAPHYLOCOCCI AND MICROCOCCI

Strain	Glutamate	Alanine	Glycine	Lysine	Ref
524/*SC*	1.0	1.8	3.2	0.6	3
H	1.0	3.2–3.7	—	0.9–1.2	9
Duncan	1.0	2.8	6.3	1.9	23
11	1.0	1.4	0.05	0.5	Present work
Oxford	1.0	1.9	4.9	1.0	Present work
M lysodeikticus	1.0	1.9–2.5	1.2–1.6	1.0	13

Cell walls prepared by the Cummins and Harris method, hydrolysed for 4 hr with 4 *N* hydrochloric acid and the contents of amino-acids determined (ref 13)

The action of lysozyme on a 'staphylococcus' strain 11 has provided some facts which also point towards possible heterogeneity of the wall mucopeptides This organism has a wall which is qualitatively similar to staphylococci, as can be seen from Table 1, although it is distinguished by a very low glycine content No glucose could be detected Its cytochrome composition, however, is different from other staphylococci and nearer that of *Micrococcus lysodeikticus* (Jackson, private communication)

Fig 1 shows the lysis of whole organisms of this strain by lysozyme When the enzyme is allowed to hydrolyse wall preparations, the optical density of the suspension falls to about 26 per cent of the

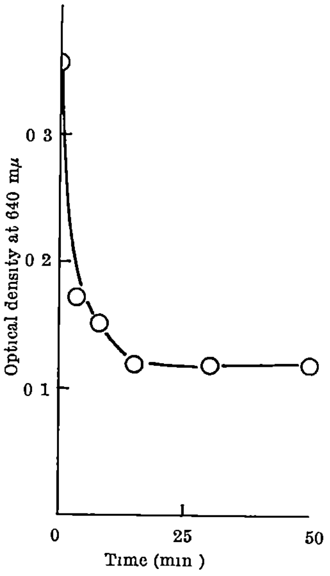

Fig 1 Lysis of 'staphylococcus' strain 11 by lysozyme A suspension of organisms grown in broth for 18 hr at 35° with agitation was prepared by centrifuging, washing twice with water, and suspending in 0.1 *M* ammonium acetate buffer *p*H 6.0 To the suspension warmed to 37° 50 μgm /ml of crystalline (Armour Products, Ltd) lysozyme were added at zero time The optical density was measured at the times indicated during incubation at 37°

Table 2 AMINO-ACID AND GLUCOSAMINE CONTENTS (EXPRESSED AS MOLAR RATIOS WITH GLUTAMATE AS 1 0) OF THE LYSOZYME SOLUBLE AND LYSOZYME INSOLUBLE PARTS OF THE CELL WALL MUCOPEPTIDES OF 'STAPHYLOCOCCUS' STRAIN 11

	Whole wall	Lysozyme residue	Lysozyme soluble
Glutamate	1 0	1 0	1 0
Alanine	1 4	1 4	1 5
Glycine	0 05	0 07	0 05
Lysine	0 5	0 6	0 5
Glucosamine	0 6†	0 46*	0 81*

* Estimated on the hydrolysate after separation of the muramic acid (cf Perkins and Rogers, ref 13)

† Estimated from a comparison of the ninhydrin colour on chromatograms when compared with that given by standard amounts of glucosamine

initial value during 24-hr incubation at 35° Nevertheless, on centrifuging at 10,000*g* for 10 min only about 40 per cent of the material in the hydrolysate remains in solution Table 2 shows the molecular composition of the soluble and insoluble parts More definite evidence of heterogeneity has been demonstrated in walls from *B subtilis* (Janczura and Rogers, unpublished observation)

These walls contain many more amino-acids than those in staphylococcus[1], but lysozyme liberates soluble material from them containing principally alanine, glutamate, diaminopimelic acid, glucosamine and muramate but leaves behind as a small insoluble residue material containing eleven or twelve amino-acids Biochemical heterogeneity of this type may well reflect the multiple-layered nature of the cell wall which has been revealed by electron microscopic examination of sectioned bacteria[12] It is with the possibility of heterogeneity of mucopeptides in mind that the following structural and biosynthetic results must be interpreted

Structural Observations

Hydrolysis of M lysodeikticus wall Brief hydrolysis of walls from *M lysodeikticus* for 20 min with 2 *N* sulphuric acid at 100° has yielded[13] three fragments, one of which (*a*) contains muramate and the four amino-acids, while two have relatively simple composition, one (*b*) contains amino-sugars in the proportion of two moles of muramic acid to one of glucosamine, the other (*c*) one mole of glucosamine, one of muramate and one of glycine The amino-group of the glycine in compound (*c*) is not free to react with fluorodinitrobenzene and it is therefore, reasonable to suppose that the carboxyl of the muramate is linked with the $-NH_2$ group of the glycine As isolated, the $-NH_2$ groups of some of the hexosamine are free, but in the original structure before hydrolysis they are probably acetylated The oligosaccharide (*b*) is different both in its electrophoretic and chromatographic behaviour from the oligosaccharide isolated by Salton[14] from hydrolysates of the wall resulting from the action of lysozyme, as might be expected from the molecular composition of the latter which contains[15] equimolar amounts of N-acetylmuramate and N-acetylglucosamine rather than the two moles of muramate to one of glucosamine present in the acid hydrolysis product

Closer examination of the action of lysozyme on walls of *M lysodeikticus* has revealed certain fallacies in the literature in the interpretation of results It has been recognized since the earliest studies of lysozyme that material reacting in the Elson–Morgan[16] N-acetylglucosamine test is liberated Recently a claim has been made[17] that larger amounts of material reacting as glucosamine rather than N-acetylglucosamine are released Examination[15] of this latter claim has, however, shown that it is likely to be partly due to the reaction of liberated reducing groups from combined N-acetylamino sugars reacting with the free[18] ε-amino groups of lysine to give artefact colour[19] in the test and is not due to hexosamine with free amino groups The reducing group of glucose itself which is also present in the wall of *M lysodeikticus* is not necessarily involved since a similar artefact colour can be obtained from lysozyme digests of walls from the lysozyme-sensitive strains of 'staphylococcus' such as strain 11, in which, as has been shown, no detectable glucose is present

Examination[15] of the colour formed in the N-acetylglucosamine test has revealed a more complicated situation The basis of the test is the heating of the substance in dilute alkali—either sodium carbonate[16] or borate[20], during which heterocyclic ring substances which react to give colour with *p*-dimethylaminobenzaldehyde are formed Examination of the time course of chromogen formation in lysozyme hydrolysates of walls during treatment with alkali reveals that smaller molecular material in them is hydrolysed by alkali under the conditions of hexosamine tests, presumably to give free reacting N-acetylglucosamine and N-acetylmuramic acid groups which are rapidly converted to chromogen Thus, the amount of 'N-acetyl-hexosamine' estimated depends upon the degree of alkaline hydrolysis which has taken place in the test Previous results for liberation of 'N-acetylglucosamine' from cell wall material by lysozyme probably reflect more upon the alkali treatment used in the method of estimation than upon the action of the enzyme itself, no free 'glucosamine' is liberated Oxidation of the disaccharide liberated by lysozyme with hypoiodite followed by hydrochloric acid hydrolysis gave no glucosaminic acid but did give a substance which may be the lactam derived from the C-1 carboxylic acid corresponding to N-acetylmuramic acid, at all events, isolated N-acetylmuramic acid gave the same substance after hypoiodite oxidation and acid hydrolysis[15]

Thus the lysozyme-produced disaccharide accounting for about 15–16 per cent of the total hexosamine in the wall is likely to be 1–4 or 1–6 N-acetylglucosamido-N-acetylmuramic acid This assumes, for the present, that this disaccharide is not a product of a transglycosidation rather than a hydrolysis Other evidence shows the linkage almost certainly to be 1–6 No evidence is yet available about the bond between C-1 of N-acetyl-muramic acid and N-acetylglucosamine, but we may for the moment suppose that part of the mucopeptide or part of one of the mucopeptides is made up of N-acetylglucosaminido-1–6 N-acetyl muramic acid with the carboxyl group of the muramate free and partly of a disaccharide in which this group is combined with glycine

If the larger, more complicated peptide isolated from acid hydrolysates comes from the same polymer, then the rest of the amino-acids may occur as a sequence linked to the glycine This discussion leaves glucose out of account Peptide amino-sugar fragments also containing glucose have been isolated from acid hydrolysates of the cell walls and it seems likely that glucose does not occur in the form of a separate polymer It is very rapidly released[13] during dilute acid hydrolysis of the wall, a behaviour reminiscent of that of fucose in the blood group substances

We have then the following evidence about structures in the wall (1) N-acetylglucosaminido-1-6-N-acetylmuramate occurs to the extent of at least 15 per cent of the total hexosamine (2) Glycyl-N-acetyl-muramido-N-acetylglucosamine or N-acetylglucosaminido-1-6-N-acetylmuramyl-glycine occurs (3) The glycine of (2) may be further linked to a peptide chain containing glutamate, alanine and lysine (4) A lysozyme-resistant[13] structure containing two molecules of muramate and one of glucosamine exists in the molecule (5) Lysozyme so fragments the molecule that the following are formed (*a*) the disaccharide already mentioned , (*b*) at least three substances diffusible through 'Cellophane' which contain both glucosamine, muramate and the four cell wall amino-acids but no glucose , (*c*) three large non-diffusible substances[14] which have some amino-sugar and almost all the glucose associated with them This profound fragmentation of the molecule suggests that the lysozyme labile bond is scattered through the molecules of the polymer or polymers rather than occurring at frequent regular intervals as part of an unbranched backbone mucopolysaccharide chain It is clearly too early to speculate further about the structure of the mucopeptides The optical specificity of the amino-acids in the various fragments has not yet been examined, although it is known that a proportion of the alanine[9,21] and all the glutamate in the walls of some strains of *Staphylococcus aureus* and in *Micrococcus lysodeikticus* is in the -D form

Biosynthesis of Staphylococcal Mucopeptides

Biosynthesis of the mucopeptides is in some respects a less complicated process than that of cell proteins , it can occur under conditions where protein formation will not occur, such as when a single cell wall amino-acid is supplied to the organism[3,22] when chloramphenicol is added to staphylococcal suspensions, thus stopping ordinary protein synthesis[3,22,23], or in *B subtilis* when aza-guanine is present, which also brings to a halt protein synthesis[24] The process of mucopeptide synthesis is, nevertheless, sensitive to penicillin[3,25], whereas protein synthesis is not[26] Even in the presence of penicillin, however, synthesis of cell wall material by suspensions of some strains of staphylococci continues for a time at a reduced rate[3] During this time abnormal mucopeptide is formed, with a smaller content of alanine relative to the amount of glutamate[3] The biosynthesis of the ribitol phosphate teichoic acid is also stopped by penicillin[4,7]

In some strains, but not in others, a uridine muramyl peptide already referred to accumulates[3,9,10] In another strain more complicated uridine peptides accumulate[11], but the walls of the organism were found[27] to be more complicated Whether or not the uridine peptides are precursors of cell wall mucopeptides remains to be proved , that uridine compounds of the amino-sugars should be involved in building up the glycosidic bonds in the structure is eminently reasonable from other work on mucopolysaccharide and polysaccharide biosynthesis, and uridinediphosphomuramate has been reported as being present in other species of organisms[18] Also present within *Streptococcus faecalis*[29] and, as we have shown, within *M lysodeikticus* and *Staphylcoccus aureus*, are larger peptides containing the same hexosamines and amino-acids as the cell wall Amino-acid is incorporated rapidly into some of these peptides (Rogers, H J , and Mandelstam, J , unpublished observations), so they also may play some part in mucopeptide biosynthesis

Table 3 EFFECT OF DILUTION ON THE EFFICIENCY OF A STAPHYLOCOCCAL SUSPENSION IN SYNTHESIZING MUCOPEPTIDE

Mass of organisms added (μgm)	Vol of supernatant	Total counts/min incorporated	Total counts/min mgm D W * × 10^3
0	0 5	57	—
12	0 5	225	14
62	0 5	563	8 1
125	0 5	870	6 5
250	0 5	1,600	6 2
12	0	118	9 8
250	0	920	3 7
1,000	0	1,975	1 9

* mgm D W = mgm dry weight of bacteria added per ml of system

Organisms (*Staphylococcus aureus* strain 524) in suspension and crush supernatant were added to make a final volume of 2 5 ml and final concentrations of 0 5 μmole of ATP and UTP, lysine and glutamate, 1 0 μmole of alanine, magnesium, cysteine and 0 22 *M* sucrose were present Radioactively labelled glycine 1 5 μmoles/ml of glycine were added containing 0 085 μc of radioactivity as ^{14}C , 1 μc of glycine gave 2 09 × 10^5 counts per min in the counting apparatus used the mixtures were incubated for 90 min at 37° and the reactions were stopped by the addition of trichloroacetic acid to a final concentration of 5 per cent (w/v) Purified cell wall (10 mgm) was added as carrier before the trichloroacetic acid at the end of the experiment The samples were then treated as for 'T C A mixed precipitates' (ref 3) The broken suspension was made by crushing the suspension in *M* sucrose containing cysteine, magnesium and phosphate in the Hughes press working at −25° to −30° The broken preparation was then diluted to ten times its initial volume with 0 1 *M* phosphate at *p*H 7 0 and centrifuged for three periods of 15 min at 1,000*g* at 0–4° , between each spinning the sediment was removed The final supernatant was used

In order to further the study of these possible intermediates, it would clearly be desirable to have some system in which the selectively permeable membrane of the living organism is no longer functional Attempts to produce active preparations free of whole living cells similar to those which others have found capable of incorporating amino-acids into cell walls[30,31] have not so far been successful Initial experiments were very hopeful so long as the efficiency of the remaining unbroken organisms was regarded as being independent of the dilution of the suspension and the presence of 'cell sap' As Table 3 shows, however, this is not so, and even when the number of whole cells was not more than 0 05–0 1 per cent of those in the initial cell suspension the incorporating activity was equivalent to 10 per cent of that by the whole unbroken preparation Part of the stimulating activity of the 'cell sap' was shown to be due to its content of nucleic acid (Table 4), a striking parallel with previous observations[30] made with broken cell preparations Some degree of specificity existed, in that nucleic acid isolated by the technique of Jones[32] from the strain of staphylococcus examined was much more effective than thymus deoxyribonucleic acid In another type of experiment, living cells were labelled in their cell walls, added to part of the crush

Table 4 , STIMULATION OF CELL WALL SYNTHESIS BY NUCLEIC ACIDS ISOLATED FROM *Staphylococcus aureus* STRAIN 524

	Total counts/min /mgm added cells × 10^3		
	Mixed TCA ppt Exp 1	Mixed TCA ppt Exp 2	Cell walls Exp 1 and 2
No additions	3 7	3 7	3 7
+ Supernatant	10 7	10 0	9 90
+ Nucleic acid	9 0	9 2	9 30

The conditions for incubation were as described in the legend to Table 3 The supernatant was the same as for the experiment shown in Table 3 and was replaced where indicated by 0 15 mgm /ml of nucleic acid (mixture of deoxyribonucleic acid and ribonucleic acid in the proportions of 7 1) isolated from *Staph aureus* 524 and 50 μgm /ml of cells were added Carrier cell wall was added as previously described (cf Table 3) and cell walls were re-isolated by the Cummins and Harris (ref 2) procedure

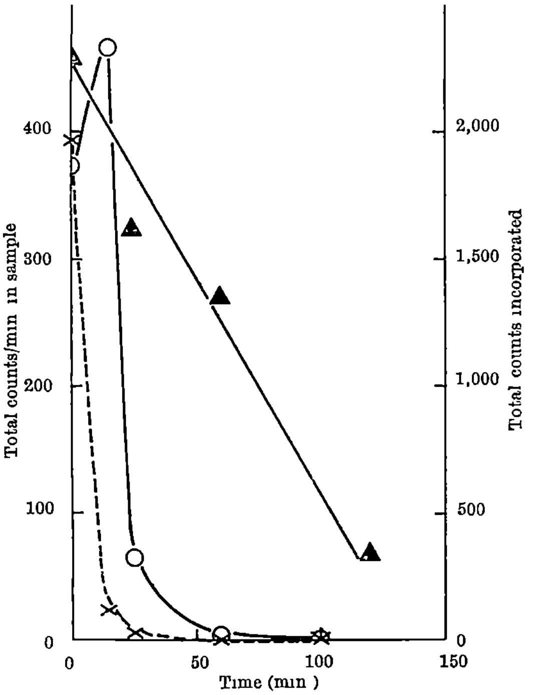

Fig 2 The sedimentation of whole cells from a broken preparation during centrifugation at 1,000*g* at 0–4° Whole cells of *Staphylococcus aureus* strain 524 were labelled in their cell walls by incubation with labelled glycine (ref 22), washed and prepared as a thick suspension which was then added to the diluted crush The crush was prepared from *Staphylococcus aureus* strain 524 by passing a thick suspension of cells in *M* sucrose through the Hughes press working at −30° The crush was then diluted with either 0 1 *M* sodium-potassium phosphate buffer, *p*H 7 0 ×, or with further *M* sucrose (▲) At the times indicated the centrifuge was stopped, and samples taken from the supernatant In order to obtain as representative samples as possible without disturbing the sediment, the pipette was moved slowly down the tube while the sample was drawn into it The samples were mixed with trichloracetic acid to give a final concentration of 5 per cent (w/v) and the precipitate washed once with 5 per cent trichloroacetic acid and dried by washing with acetone and ether The dried precipitates were weighed and assayed for radioactivity at infinite thickness Total radioactive counts (that is, weight × specific activity) are recorded ○ shows the ability of samples of the supernatants to incorporate radioactive glycine into cell wall material when tested under the conditions given in the legend to Table 3

and incorporating activity of the cell wall and residual radioactivity due to whole cells remaining in the supernatant after centrifugation at 0–4° compared. Two observations from Fig 2 can be made (1) that centrifugation at 1,000*g* in the presence of sucrose can be a very inefficient way of removing whole cells , (2) a difference between the rate of deposition of whole cells and the incorporating activity of the preparations is apparent, thus suggesting that incorporation might be taking place into some particle less dense than the whole cell This difference, however, can be largely accounted for by the increasing efficiency of the decreasing number of whole cells

[1] Salton, M R J , *Biochim Biophys Acta*, **10**, 512 (1953)
[2] Cummins, C S , and Harris, H , *J Gen Microbiol* , **14**, 583 (1956) Cummins, C S , *Intern Rev Cytol* , **5**, 25 (1956)
[3] Mandelstam, J , and Rogers, H J , *Biochem J* (in the press)
[4] Mitchell, P , and Moyle, J , *J Gen Microbiol* , **5**, 981 (1951)
[5] Salton, M R J , and Horne, R W , *Biochim Biophys Acta*, **7**, 177 (1951)
[6] Baddiley, J , Buchanan, J G , and Carss, B , *Biochim Biophys Acta*, **27**, 220 (1958) Armstrong, J J , Baddiley, J , Buchanan, J G , and Carss, B , *Nature*, **181**, 1692 (1958)
[7] Mitchell, P , and Moyle, J , *Proc Phys Soc* (Edin), **27**, 79 (1958)
[8] Brown, A D , *Biochim Biophys Acta*, **28**, 445 (1958)
[9] Park, J T , and Strominger, J L , *Science*, **125**, 99 (1957)
[10] Park, J T , *J Biol Chem* , **194**, 897 (1952)
[11] Ito, E , Ishimoto, N , and Saito, M , *Nature*, **181**, 906 (1958), *Arch Biochem Biophys* , **80**, 431 (1959)
[12] Kellenberger, E , and Ryter, A , *J Biophys Biochem Cytol* , **4**, 323 (1958)
[13] Perkins, H R , and Rogers, H J , *Biochem J* (in the press)
[14] Salton, M R J , *Biochim Biophys Acta*, **22**, 495 (1956)
[15] Perkins, H R , *Biochem J* (in the press)
[16] Elson, L A , and Morgan, W T J , *Biochem J* , **27**, 1824 (1933) Aminoff, D , Morgan, W T J , and Watkins, W M , *Biochem J* , **51**, 379 (1952)
[17] Brumfitt, W , Wardlaw, A C , and Park, J T , *Nature*, **181**, 1783 (1958)
[18] Ingram, V M , and Salton, M R J , *Biochim Biophys Acta*, **24**, 9 (1957)
[19] Immers, J , and Vasseur, E , *Nature*, **165**, 898 (1950)
[20] Reissig, J L , Strominger, J L , and Leloir, L F , *J Biol Chem* , **217**, 959 (1955)
[21] Salton, M R J , *Nature*, **180**, 338 (1957)
[22] Mandelstam, J , and Rogers, H J , *Nature*, **181**, 956 (1958)
[23] Hancock, R , and Park, J T , *Nature*, **181**, 1050 (1958)
[24] Richmond, M H , *Biochim Biophys Acta* (in the press)
[25] Park, J T , *Biochem J* , **70**, 2P (1958)
[26] Strominger, J L , *J Biol Chem* , **224**, 509 (1957)
[27] Ishimoto, N , Saito, M , and Ito, E , *Nature*, **182**, 959 (1958)
[28] Cifonelli, J A , and Dorfman, A , *J Biol Chem* , **228**, 547 (1957)
[29] Abrams, A , *J Biol Chem* , **230**, 949 (1958)
[30] Gale, E F , and Folkes, J P , *Biochem J* , **57**, 661 (1955)
[31] Gale, E F , Shepherd, C J , and Folkes, J P , *Nature*, **182**, 592 (1958)
[32] Jones, A S , *Biochim Biophys Acta*, **10**, 607 (1953)

RELATIONSHIP BETWEEN PHOTOPHOSPHORYLATION AND THE HILL REACTION

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ARISING from the work of Hill[1], it is now well known that isolated chloroplasts illuminated in the presence of a suitable hydrogen acceptor will evolve oxygen

$$2A + 2H_2O \xrightarrow[\text{chloroplasts}]{\text{light}} 2AH_2 + O_2$$

Little doubt now remains that photolysis of water in the Hill reaction with production of reducing power and oxygen represents a partial model of photosynthesis in a cell-free system

Recently, Arnon, Whatley and Allen[2] have made the important observation that when a phosphate acceptor system (adenosine diphosphate, Mg^{2+} and PO_4^{3-}) is included in the Hill reaction system with coenzyme II or ferricyanide as hydrogen acceptor, oxygen evolution is stoichiometrically related to phosphate esterified into adenosine triphosphate Moreover, in the ferricyanide reaction the rate of production of oxygen is stimulated two-fold by addition of the phosphate acceptor

In the present work a similar stimulation of the Hill reaction rate by phosphate acceptors has been observed with coenzyme II as hydrogen acceptor The reduction of substrate amounts of pyridine nucleotides by catalytic amounts of chlorophyll has been shown to require a protein factor readily extractable from chloroplasts[3],[4] A preparation of this factor was obtained from spinach leaves by the method of San Pietro and Lang[4] Chloroplasts were obtained by grinding spinach leaves in 0 4 *M* sucrose containing 0 05 *M tris* buffer *p*H 7 8 and 0 01 *M* sodium chloride The fraction sedimenting between 500 and 1,500*g* was resuspended in the same medium Reduction of added pyridine nucleotide was followed by observing the increase in optical density at 340 mμ after a period of illumination The blank cell contained all the reagents except pyridine nucleotide Fig 1 shows that the reduction of coenzyme II is stimulated 2 5-fold by the presence of the phosphate acceptor system and that all the components of this system are necessary for appreciable stimulation In these experiments, contrary to the findings of San Pietro and Lang[4], coenzyme I was not reduced either in presence or absence of the phosphate acceptor

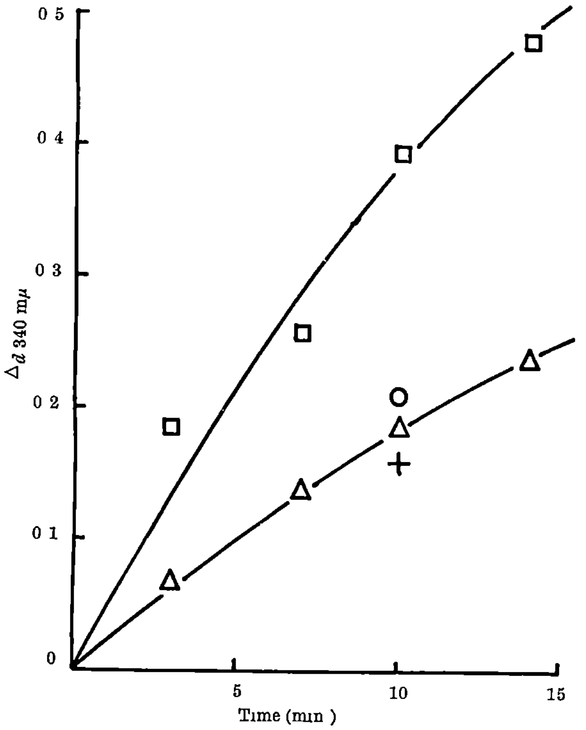

Fig 1 Effect of phosphate acceptor system on the rate of reduction of coenzyme II by isolated chloroplasts The reaction mixture contained, in a final volume of 2 5 ml , leaf protein 0 26 mgm , chloroplasts containing 23 μgm chlorophyll and (except where otherwise indicated) the following in micromoles *tris* buffer, *p*H 7 4, 80 , coenzyme II, 0 5 , adenosine diphosphate, 2 , magnesium chloride, 10 , phosphate buffer, *p*H 7 4, 80 Illumination by 500-watt projector lamp at 1 ft temp 16° □, complete system , O, magnesium omitted , +, adenosine diphosphate and magnesium omitted , Δ, adenosine diphosphate, magnesium and phosphate omitted

Arnon *et al* [3] in their observations on phosphorylation accompanying coenzyme II reduction by illuminated chloroplasts have shown that addition of catalytic amounts of flavin mononucleotide or menadione abolish both oxygen evolution and the accumulation of reduced coenzyme II and stimulate phosphorylation A probable mechanism for this effect suggested itself in the course of the present work All the leaf and chloroplast protein fractions active in mediating coenzyme II reduction were found also to possess a very active coenzyme II diaphorase activity similar to that reported by Avron and Jagendorf[5] Diaphorase in the presence of a rapidly autoxidizable hydrogen acceptor should function as a reduced pyridine nucleotide oxidase Menadione and flavin mononucleotide are listed by Avron and Jagendorf as hydrogen acceptors for their coenzyme II diaphorase from chloroplasts Their effect in reoxidizing reduced coenzyme II produced photochemically by a chloroplast system containing San Pietro and Lang leaf extract is shown in Fig 2 Here also pyocyanine is shown to have a similar

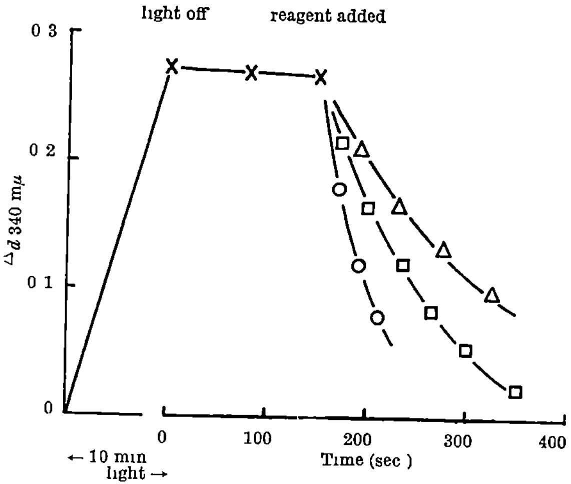

Fig 2 Reoxidation of photochemically reduced coenzyme II by some catalysts of photophosphorylation Reaction mixture as Fig 1 (complete system) At the time indicated 0 05 μmole of the following added Δ, flavin mononucleotide , □, pyocyanine , O, menadione

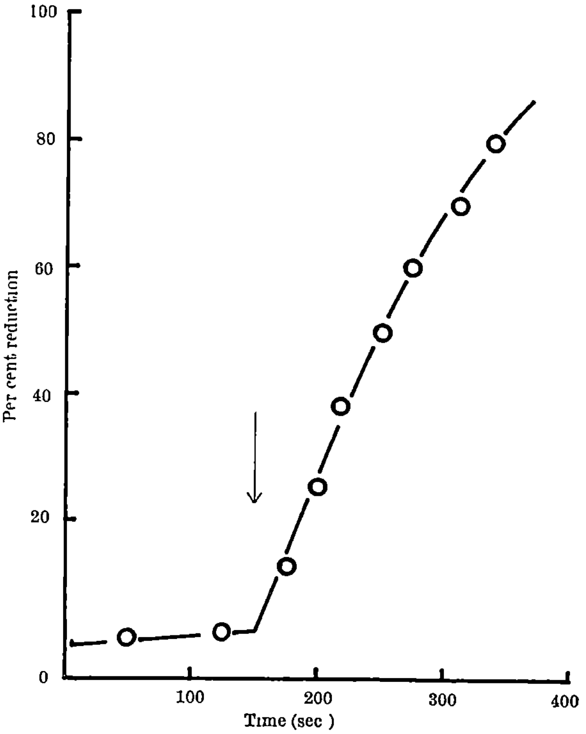

Fig 3 Catalytic effect of pyocyanine in promoting reduction of methæmoglobin by illuminated chloroplasts Reaction mixture contained chloroplasts equivalent to 35 μgm chlorophyll, whale muscle methæmoglobin, 0 35 μmole , phosphate buffer, *p*H 7 4, 150 μmoles and water to 5 ml Pyocyanine (0 05 μmole) added at time indicated by arrow Illumination by 500-watt projector lamp at 1 ft , temp 18°

activity Pyocyanine has been found by Walker and Hill[6] to resemble flavin mononucleotide and menadione as an active catalyst of photophosphorylation It has not previously been recorded as an autoxidizable hydrogen acceptor of the chloroplast diaphorase

These observations suggest that these photophosphorylation catalysts may function by maintaining a level of oxidized coenzyme II in competition with the light-driven reduction of the coenzyme In the intact leaf this level would be maintained by utilization of the reduced coenzyme in carbon dioxide fixation An objection to the concept is that the catalysts stimulate phosphorylation by chloroplasts in the absence of added coenzyme II and leaf extract It has, however, been shown that isolated chloroplasts contain significant amounts of pyridine nucleotides[7] Moreover, in the present work it was found that both the diaphorase and pyridine nucleotide reductase activities remained in association with the chloroplasts isolated in isotonic media Such chloroplasts in conjunction with pyocyanine do in fact bring about re-oxidation of reduced coenzyme II in the absence of added leaf extract

A necessary condition for a mechanism of this kind to function is that the photophosphorylation catalysts should be shown to be reduced by illuminated chloroplasts This was demonstrated indirectly by using the catalysts to couple the reducing power of illuminated chloroplasts to the reduction of methæmoglobin Methæmoglobin is not reduced directly by isolated chloroplasts[8] Fig 3 shows that addition of a catalytic amount of pyocyanine to the system results in a rapid reduction of the hæm-protein It thus appears that the pyocyanine can act as a hydrogen acceptor in the Hill reaction, but in the absence of a further reduction step is rapidly reoxidized by free oxygen or its precursors in the system Similar results were obtained with flavin mononucleotide and menadione

The experimental details of this work will be published more fully elsewhere

[1] Hill, R , *Proc Roy Soc* , B, **127**, 192 (1939)

[2] Arnon, D I , Whatley, F R , and Allen, M B , *Biochim Biophys Acta*, **32**, 47 (1959)

[3] Arnon, D I , Whatley, F R , and Allen, M B , *Nature*, **180**, 182 (1957)

[4] San Pietro, A , and Lang, H M , *J Biol Chem* , **231**, 211 (1958)

[5] Avron, M , and Jagendorf, A T , *Arch Biochem Biophys* , **65**, 475 (1956)

[6] Walker, D A , and Hill, R , *Biochem J* , **69**, 57*P* (1958)

[7] Krogmann, D W , *Arch Biochem Biophys* , **76**, 75 (1958)

[8] Davenport, H E , Hill, R , and Whatley, F R , *Proc Roy Soc* , B, **139**, 346 (1952)

STRUCTURE OF α-HYDROXYACETYLENE COMPLEXES OF PLATINUM(II)

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THE best characterized co-ordination compounds containing olefinic hydrocarbons as ligands are those of platinum(II) They were discovered in 1830[1] Nevertheless, corresponding complexes of acetylenic hydrocarbons have proved somewhat difficult to obtain, and their preparation has been reported only recently[2,3] Our study[3] showed that the stability of the complexes depends critically upon the structure of the acetylenic hydrocarbon, $R\,C \equiv C\,R'$ It appeared that the more electronegative and conjugative the nature of the hydrocarbon radicals R and R' the lower the stability of the complexes It is therefore surprising that complexes of the dihydroxyacetylene, $Me_2C(OH)\,C \equiv C\,C(OH)Me_2$ (*ac*), with strongly electronegative hydroxyl groups attached to the α-carbon atoms should form relatively very stable complexes of the types $K[acPtCl_3]$, *cis*-$[ac,NH_3PtCl_2]$ and *trans*-$[ac,\text{amine}PtCl_2]$[4], and so we have prepared a series of complexes of α-hydroxyacetylenes and their methyl ethers, compared their stabilities, and examined their infra-red spectra to see whether the hydroxyl groups contribute in some direct way to the stability of the complexes

The hydroxyacetylenes form complexes of the type $K[acPtCl_3]$ by direct reaction with aqueous K_2PtCl_4 or with $K[C_2H_4PtCl_3]$ in acetone, but up to the present it has not been possible to prepare from these the non-ionic bridged complexes $ac_2Pt_2Cl_4$ On the other hand, the acetylenic hydrocarbons form the bridged complexes directly, and the salts of the type $K[acPtCl_3]$ are usually unstable in water, eliminating potassium chloride and reverting to the bridged complex The methyl ethers form considerably less stable complexes than do the hydroxyacetylenes

In Table 1 we list a representative selection of the complexes of hydroxyacetylenes and their methyl ethers, with pertinent infra-red spectral data

In these complexes the triple bond is co-ordinated to the metal as shown by the lowering of some 200 cm^{-1} in the triple bond stretching frequency ($\nu_{C \equiv C}$) This should be compared with the lowering of 150 cm^{-1} observed in the corresponding olefin complexes[5] It is interesting, too, that the hydroxyl groups are also profoundly modified when the hydroxyacetylenes form complexes, the O—H stretching frequency ($\nu_{O\text{-}H}$) being lowered by 110–140 cm^{-1}, depending on the substituent on the α-carbon atom This fact, and a number of supporting observations which cannot all be presented here, lead us to suggest that the electron pairs on the oxygen atoms in the hydroxy-

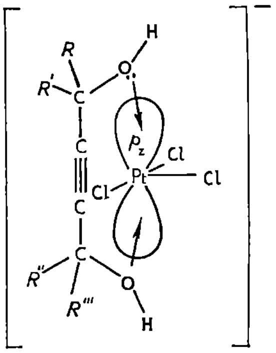

Fig 1

Table 1 INFRA-RED DATA RELATING TO COMPLEXES OF HYDROXYACETYLENES WITH PLATINUM(II) AT 20° C

Hydroxyacetylene (*ac*)			Complexes				
			K[*ac*PtCl$_3$]	*trans*-[*ac*,*pip*PtCl$_2$]‡			
Formula	$\nu_{C\equiv C}$* (cm^{-1})	ν_{O-H}† (cm^{-1})	$\nu_{C\equiv C}$* (cm^{-1})	m p °C (dec)	$\nu_{C\equiv C}$* (cm^{-1})	ν_{O-H}† (cm^{-1})	ν_{N-H}† (cm^{-1})
Me_2C(OH) C≡C C(OH)Me_2	2,248§ 2,224	3,612	2,010	112–114	2,045	3,502	3,229
Me_2C(OH) C≡C C(OMe)Me_2	**	3,610	2,004	‡‡		3,495	3,221
Me_2C(OMe) C≡C C(OMe)Me_2	**	—	1,994	77–79	2,032	—	3,216
Me_2C(OH) C≡C C(OH)$MePh$	**	3,606	2,004	115–118	2,026	3,478	3,224
Bu^t C≡C C(OH)Me_2	2,228††	3,612	2,008	83–86	2,046	3,500	3,223
Bu^t C≡C C(OH)$MePh$	2,259 2,224	3,601	2,009	107–109 5	2,041	3,475	3,224

* Measured in 'Nujol' mulls at 20° C ν(C≡C) stretching gives only weak bands in the infra-red spectrum and the above assignment must be regarded as tentative † Measured in carbon tetrachloride at 20° C ‡ *pip* = piperidine § Raman spectrum, see ref 10 ** Not visible †† Liquid film ‡‡ Viscous oil which did not crystallize

and methoxy-acetylenes interact with the vacant $6p_z$-orbital of the platinum atom as shown in Fig 1 Alternatively, in the case of the hydroxyacetylenes, the hydrogen atoms of the hydroxyl groups may interact with electrons in the $5d_{z^2}$-orbital of the metal Thus the unexpected stability of the complexes would arise because the hydroxyacetylenes behave as multidentate ligands, and the platinum(II) atom has a very distorted octahedral configuration such as has been demonstrated[6] in certain complexes of the type $[o\text{-}C_6H_4(AsMe_2)_2]_2PtI_2$

Intermolecular hydrogen bonding between the hydroxyl groups, or a hydroxyl group and a chlorine atom, is rejected as the cause of the lowering in the O—H stretching frequency, because there are no bands which can be assigned to free hydroxyl groups in the spectra of carbon tetrachloride solutions of the complexes, and the spectra of the solutions are unchanged on addition of dioxane Intramolecular hydrogen bonding between the hydroxyl groups and the chlorine atoms is sterically impossible if the triple bond lies perpendicular to the plane of the platinum and chlorine atoms, as does the double bond in the olefin complexes[7,8] In alkyne complexes of the type *trans*-[Bu^t C≡C R,piperidinePtCl$_2$], the N—H stretching frequency (ν_{N-H}) is independent of the group R in the alkyne, having a value[3] of 3,221 cm^{-1} In the hydroxyacetylene complexes it changes considerably as substitution about the α-carbon atom is changed, and especially on methylation of the hydroxyl groups This suggests that there is a route from the N—H bond to the place of substitution other than through the triple bond On the other hand, the N—H frequency (3,228 cm^{-1}) of the corresponding allyl alcohol complex, in which the hydroxyl group would not be expected to interact with the $6p_z$- or $5d_{z^2}$-orbital for steric reasons, is identical with that of the corresponding complex of allyl methyl ether

The stability of the dihydroxyacetylene complexes is highly dependent on the structure of the glycol, RR'C(OH) C≡C C(OH)$R''R'''$ When $R = R' = R'' = R''' = Me$, stable complexes, Na[*ac*PtCl$_3$] and K[*ac*PtCl$_3$], are readily formed, but the introduction of even one hydrogen atom (R = H, $R' = R'' = R''' = Me$) leads to the production of unstable gums, presumably[9] due to oxidation of the —CH(OH)— group to C=O Complexes of acetylenic glycols containing one or two phenyl groups (for example, $R = R'' = Ph$, $R' = R''' = Me$) are less stable and have been isolated as potassium salts but not as sodium salts Hydroxyacetylenes with phenyl groups conjugated to the triple bond, for example, Ph C≡C C(OH)Me_2 and o-HO C$_6$H$_4$ C≡C C$_6$H$_4$ OH-o and the diyne diol Me_2C(OH) C≡C C≡C C(OH)Me_2, also give unstable complexes, which we have not been able to isolate as sodium or potassium salts, but which might be isolated as salts of larger cations[2] Again it appears that absence of conjugation and a high positive inductive effect of the substituent groups favour the formation of stable complexes

[1] Zeise, W C, *Magaz f Pharm*, **35**, 105 (1830)

[2] Bukhovets, S V, and Pukhova, N K, *Zhur Neorg Khim*, **3**, 1714 (1958)

[3] Chatt, J, Duncanson, L A, and Guy, R G, *Chem and Indust*, 430 (1959)

[4] Gelman, A D, Bukhovets, S V, and Meilakh, E A, *C R Acad Sci U S S R*, **46**, 105 (1945) Bukhovets, S V, *Izvest Sekt Platiny Drug Blagorod Metal*, *Inst Obschchei Neorg Khim*, **29**, 55 (1955) Bukhovets, S V, and Molodova, K A, *Zhur Neorg Khim*, **2**, 776 (1957), **3**, 1540 (1958)

[5] Chatt, J, and Duncanson, L A, *J Chem Soc*, 2939 (1953)

[6] Harris, C M, Nyholm, R S, and Stephenson, N C, *Nature*, **177**, 1127 (1956)

[7] Mellor, D P, and Wunderlich, J A, *Acta Cryst*, **7**, 130 (1954), **8**, 57 (1955)

[8] Bokii, G B, and Kukina, G A, *Akad Nauk U S S R Krist*, **2**, 400 (1957)

[9] Helmkamp, G K, Carter, F L, and Lucas, H J, *J Amer Chem Soc*, **79**, 1306 (1957)

[10] Cleveland, F F, and Murray, M J, *J Amer Chem Soc*, **62**, 3186 (1940)

HETEROSIS AND THE GENETICS OF COMPLEX CHARACTERS

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HETEROSIS is one of a group of phenomena for which an adequate genetic interpretation has not emerged The group comprises inbreeding depression, hybrid stability or homœostasis, general and specific combining ability, as well as hybrid vigour in its broadest sense In discussing the role of inbreeding and the superior yield of hybrids, Fisher[1] concluded that the removal of deleterious recessives as a result of inbreeding could account for not more than 1 per cent of the improvement in yield in hybrids, and that increases of the order of 20 per cent remained to be explained Interpretations based on the superiority of the heterozygote or 'over-dominance'[2] have not proved entirely acceptable because whenever over-dominance has been investigated using genetic markers, it has not been found generally to occur[3]. In the absence of a clear-cut unifying hypothesis, present-day concepts of heterosis have become surrounded by highly sophisticated escape clauses involving all the known intricacies of gene action.

Heterosis and its allied expressions are properties of quantitative characters, particularly of such characters as yield, stature, viability and reproductive efficiency. That all expressions of this kind are complex interactions between simpler growth processes is immediately obvious, and this common denominator of quantitative characters is frequently referred to in discussions on heterosis. Nevertheless, the implications inherent in the absence of a direct relationship between gene and complex phenotypic expressions are seldom recognized in interpretation.

In one of the first attempts at explaining hybrid vigour, Keeble and Pellew[4] suggested that the inheritance of height in peas could be explained on the basis of two complementary loci each possessing one dominant and one recessive allele. Excess height in the hybrid resulted from the complementarity of dominant alleles from opposite parents, one conditioning length of internode and the other thickness of stem. (Although in certain circumstances thickness of stem may contribute to stature in plants, it should be noted that the components mostly directly concerned with height are internode length and internode number. This, however, does not affect the principles revealed by the work.) The genetic interpretation advanced by Keeble and Pellew achieved meaning and simplicity only because of the recognition that stature as a measurable character was not a primary expression of gene function, but resulted from multiplicative interaction on the phenotypic level between components which segregated in a manner suggesting direct genic control. The components of height in this material were not heterotic, and nothing more complicated than dominance was necessary to provide an adequate genetic explanation of the results. This early model of the behaviour of heterotic characters, although widely quoted as a special case, has not been fully explored and understood in later work. Hagberg[5,6], although recognizing a similar system in data on *Galeopsis* under the term 'combination heterosis', considered it could be different from 'transgressive heterosis' in which the hybrid is superior in one or more of the components of growth. In this connexion he neglected the most important aspect underlying Keeble and Pellew's interpretation, namely, that height in the pea remained genetically transgressive only so long as the components of height remained unidentified. The complexity of quantitative characters generally is such that the resolution of ultimate cell processes is a matter of utmost difficulty. In these circumstances, therefore, it is more rational to suspect the unitary nature of the component characters than to attribute hypothetical properties to the genetic system when departures from a complementary model are encountered.

Recent evidence from a study of inheritance of yield in the tomato has indicated that systems basically similar to the model governing height in the pea may be of common occurrence. It seemed, therefore, desirable to inquire how far the large body of experimental fact available concerning heterosis and allied phenomena fits in with a simple genetic system when due weight is given to interactions on the phenotypic level between the components of complex expressions.

Heterosis for Yield in the Tomato

The five characters—number of flowers, date of first flower, average weight of fruit, number of fruit and yield of fruit—were studied in three F_1 hybrids. The parents and their F_1 hybrids were compared using means of thirty replicates set out in randomized blocks.

None of the hybrids exceeded the better parent in any of the characters with the exception of yield per plant. Yield in all three hybrids exceeded the highest yielding parent. Yield when measured as weight is a product of number and weight of fruit, and in two of the hybrids number of fruit equalled the 'mid-parent' while the average weight of fruit was slightly in excess of this value. The third hybrid inherited phenotypic dominance for a high number of fruit from one of its parents but in weight of fruit it was only slightly in excess of the lower parent. Heterosis in the compound character was a product of various levels of expression of the components in the F_1, ranging from dominance of the better parent to a slight excess over the poorer parent. Heterosis, therefore, is clearly a property of the phenotype, and is conditioned by the nature of the association between the unit characters in the parents. When two parents differ reciprocally for two interacting components, and if the F_1-levels compensate one another in such a way that their product is greater than in the parent, heterosis is inevitable. Table 1 gives a simple example showing the consequence of mating reciprocally different parents.

Table 1

	Component *A* fruit number	Component *B* fruit weight	Yield
Parent *X*	3	1	3
F_1 (heterosis for yield)	2	2	4
Parent *Y*	1	3	3

The genetic system in the above model is one of blending inheritance, and it is difficult and unnecessary to envisage the operation of the remotest form of interaction on the genetic level. The genes or gene products controlling average weight and number of fruit need not and probably do not interact in the sense that an enzyme and a precursor might interact in a synthesis. Complex characters such as yield can be based on units of the genetic system which act completely independently of one another. Interaction occurs on a higher level of organization, among the components of the phenotype. Thus to interpret hybrid vigour in terms only of gene interaction is a basic misconception which has contributed greatly to the present confused state of the subject.

The system described in the tomato has wider application as can be seen from investigations on the inheritance of yield in wheat[7]. Yield of grain and the component characters weight per grain, grain per spikelet, spikelets per ear, ears per plant, were studied in all possible crosses between four varieties. None of the components showed heterosis, and their levels in

F_1 hybrids were on average slightly in excess of the 'mid-parent' Owing to the small number of comparisons possible in a 4 × 4 diallel cross, one cannot determine with any degree of certainty whether the excess was real Grain yield in all crosses was heterotic, the average yield of the parents and F_1 families was 31 9 ± 0 76 and 37 7 ± 1 02 respectively The authors interpreted this behaviour as being the result of multiplicative as distinct from additive gene action, and concluded "it can be said with confidence that gene interaction plays a part in determining the control of this character" It now seems doubtful whether an interpretation based exclusively on genetic considerations was entirely justified

Detailed examination of the individual wheat crosses shows that all six parental combinations possessed varying patterns of inequality such as was described for the tomato hybrids Four of the six were reciprocally different for all four components Since the component-levels in the hybrids were close to, or slightly in excess of, the 'mid-parent', heterosis for grain yield was inevitable In wheat, as in the tomato, an essentially additive genetic system conditions a multiplicative somatic basis to yield which, when analysed as a simple character, leads erroneously to a non-additive genetic interpretation

In a further study on heterosis among 153 hybrids in a diallel cross of 18 inbred lines of the tomato[8], further aspects of heterosis have been revealed which are relevant to this discussion First, in certain crosses heterosis has been found for yield components such as number of fruit, and this is interpreted as evidence that the component itself may be a product of sub-units Secondly, heterosis for both yield and its components was expressed only in hybrids between the poorer parents Hybrids involving the best parents were inferior to the high parent in the crosses The best varieties possess optimal levels in the yield components whereby maximal yields are achieved The highest levels of yield in the tomato can be expressed in homozygotes There is therefore no advantage for an inbreeding species such as the tomato in heterozygosity *per se* Thirdly, the components, number and weight of fruit, are negatively correlated, $r = -0\ 66$ ($n = 18$) and $-0\ 70$ ($n = 153$) in the parents and hybrids respectively This implies that in the course of the production of a certain finite weight of fruit, a variety producing large numbers will have small fruit and vice versa The maximal level at which each single component can function separately is far in excess of what can be achieved by their product The phenotype cannot sustain the production capacity that potentially resides in the multiplicative relationships between maxima at each of the unitary divisions of a complex expression When the limits for the respective functions are pushed too far by selection, or by inbreeding in outbreeders, a physiological breakdown occurs This frequently expresses itself as sterility, reduced viability or susceptibility to disease[9–11], and may be the basis of concepts of physiological limits[12]

Heterosis and Inbreeding Depression

Inbreeding is invariably associated with loss of vigour in cross-fertilizing species The commonly accepted explanation for this behaviour is based on the dominance hypothesis, and on the segregation of homozygous genotypes The extent of the average depression in a randomly breeding population where there is no selection depends only on the relative difference in expression between the segregating dominant and recessive alleles A genetic system which is strictly additive in expression cannot account for average inbreeding depression because, in the absence of selection, gene frequencies remain unchanged and the mean of the inbred population is therefore unaltered This appears at first sight to exclude the possibility of commonly occurring systems such as were described for tomato and wheat being concerned in inbreeding depression

The dominance hypothesis, despite the fit to average values of inbreeding, presents to my mind one unattractive feature Correspondence between experimental evidence and the dominance hypothesis centres around progeny averages, and the drop in vigour is related to the frequency of the homozygous recessive which after about five generations of selfing will be approaching the limit of $\frac{1}{2}$ at each locus The homozygous dominant will also have the same frequency, and for n loci the frequency will be $(\frac{1}{2})^n$ The failure in practice to isolate vigorous homozygous dominants has, on the dominance hypothesis, been attributed to the size of n and to linkage A purely mechanistic explanation of this kind is not entirely acceptable for the interpretation of a vital process Furthermore, in view of the thousands of inbred lines that have by now been studied in maize, it is inconceivable that chance recombinants of near maximal expression would not have appeared if the cause was one merely of permutation It must also be noted in this connexion that the chance of isolating recombinants will depend not on the potential n, but on that portion which is heterozygous In crop plants such as maize in which some form of selection for vigour has been practised for centuries, the number of unfixed loci may be fewer than is generally assumed in attempts to make the dominance hypothesis acceptable It may be prudent, therefore, to explore other possible factors of causality

The negative correlation between the components of complex expressions and the concept of physiological limit may provide the missing factor necessary to explain inbreeding depression in terms of additive genetic factors Selection experiments already mentioned clearly indicate the undesirable consequences of extremes of selection and of genetic fixation above the optimal level for fitness In terms of the components of fitness, physiological breakdown means that the tolerance-level of the product of component interaction has been exceeded Too many components are simultaneously at too high a level A proportion of the genotypes following inbreeding of heterozygotes should also show loss of fitness similar to that resulting from intense selection Multiple homozygotes for hypermorphic alleles segregating after inbreeding represent genotypes where all the components are simultaneously at a high level, and might be expected to belong to a class where fitness is severely reduced They are the equivalent of a highly selected, closed population where sterility, susceptibility to disease or other forms of debilitation are reducing fitness

The elimination of dominants has been demonstrated by Fisher[13] in populations of *Paratettix texanus* in which it was estimated that double dominants were eliminated to the extent of not less than 40 per cent in each generation The mechanism underlying this selective elimination of genotypes is almost certainly physiological and corresponds very closely to the system postulated here to account for inbreeding depression

If, as seems likely from the above considerations, 'compounds' of dominants or of hypermorphic alleles are to a greater or lesser degree self-eliminating in outbreeders, the dominance hypothesis is not the only explanation for inbreeding depression The pattern fits additive gene action equally well

A distinction, therefore, has to be made between gene interaction and the interrelations of the component parts of the phenotype Phenotypic characters may be multiplicative and may consequently show a mutually dependent relationship while the gene system is strictly additive and its units are strictly independent in function Heterosis in complex characters has been shown here to occur in hybrids simply as a result of a reciprocal inequality of independent gene action in the parents Given reciprocal inequality in the levels of component characters in the parents, intermediate levels in hybrids inevitably lead to heterosis in the complex character It appears, therefore, that many of the difficulties that are encountered in the interpretation of heterosis arise out of the failure to recognize the component parts of complex expressions

Multiplicative interaction between adjusted levels of component characters may govern the control of the physiological limit, as is indicated by negative correlations between components of yield in the tomato It is suggested that mal-adjusted, maximal levels of expression in sub-characters may be responsible for inbreeding depression in outbreeding species leading to the self-elimination of genotypes homozygous for several dominant or hypermorphic alleles. Inbreeding depression, like heterosis, may therefore be explained simply on the basis of interactions on the somatic level which are controlled by a complementary, essentially additive genetic system

[1] Fisher, R A , "Theory of Inbreeding" (Oliver and Boyd, 1949)
[2] Hull, F H , *J Amer Soc Agron* , 38, 1100 (1946)
[3] Schuler, J F , and Sprague, C F , *Genetics*, 41, 281 (1956)
[4] Keeble, F , and Pellew, C , *J Genet* , 1, 47 (1910)
[5] Hagberg, A , *Hereditas*, 38, 221 (1952)
[6] Hagberg, A , *Hereditas*, 39, 349 (1953)
[7] Whitehouse, R N H Thompson, J B , and Ribeiro, A M , *Euphytica*, 7, 147 (1958)
[8] Williams, W , and Gilbert, N (in the press)
[9] Mather, K , and Harrison, B J , *Heredity*, 3, 1, 131 (1949)
[10] Lerner, I M , and Dempster, E R , *Heredity*, 5, 79 (1951)
[11] Lerner, I M , "Genetic Homeostasis" (Oliver and Boyd, 1954)
[12] Falconer, D S , and King, J W B , *J Genet* , 51, 561 (1952)
[13] Fisher, R A , *Ann Eugenics*, 9, 109 (1939)

TURNIP YELLOW MOSAIC VIRUS NUCLEOPROTEIN PARTICLES WITH DIFFERING BIOLOGICAL AND PHYSICAL PROPERTIES

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PREVIOUS work[1] has shown that purified preparations of turnip yellow mosaic virus contain two types of particle One is a nucleoprotein containing 37 per cent of ribonucleic acid within a roughly spherical shell of protein The other is an apparently identical protein containing no ribonucleic acid The nucleoprotein is infectious while the protein is not The ratio of nucleoprotein to protein particles in the preparations is close to 2 1[1,2] The sedimentation patterns obtained in the ultracentrifuge with both these components give no indication of inhomogeneity[1,3]

The value of density gradient centrifugation under equilibrium conditions in strong cæsium chloride solutions for the fractionation of macromolecules has recently been demonstrated[4,5]

We have now found, using sedimentation into dense cæsium chloride solutions under non-equilibrium conditions, that the nucleoprotein particles of turnip yellow mosaic virus fall into at least two classes with respect to density and infectivity

Turnip yellow mosaic virus was isolated from infected chinese cabbage plants by the ammonium sulphate procedure[1] or by differential centrifugation Preliminary tests with whole virus preparations showed that incubation with strong cæsium chloride solutions for 2 hr at room temperature, followed by 14 hr at 4°, had no detectable effect on the infectivity of the virus To avoid anomalous effects due to crystallization or precipitation of the virus at room temperature in the strong salt solutions employed during sedimentation, all manipulations were carried out at temperatures between 4° and 10° C

In the sedimentation experiments 1–10 mgm of a virus preparation in solution in 0 1–0 6 ml water was layered over 3 5 ml of cæsium chloride solution (density = 1 39–1 43) in a 'Lusteroid' tube The samples were then centrifuged for 200–240 min at 32,000 r p m in the Spinco model L preparative ultracentrifuge using the No $39S$ rotor Under these conditions the virus protein component stays in the boundary between the water layer and the cæsium chloride solution The nucleoprotein sediments through the salt solution and resolves into bands which can be located visually by scattered light (Fig 1)

The various components were withdrawn by piercing the wall of the tube with the needle of a hypodermic syringe, and dialysed to remove salt The bands cannot be removed quantitatively by this procedure, but other methods we have tested lead to substantial mixing of closely spaced bands Estimates of relative amounts of material in various bands were based on the ultra-violet absorption curves of the extracted samples Such estimates on duplicate pairs of bands varied by as much as 25 per cent

In preparations of virus made by the ammonium sulphate procedure, two sedimenting bands appear. The faster-sedimenting band (B_2) usually contains 1/5–1/20 as much material as the slower band (B_1) If these two bands are removed and the material from several tubes combined and run again, each band shows a slight contamination with the other on the second run A third sedimentation usually gives material with no observable contamination This result suggests that the bands are not produced by the action of cæsium chloride on a uniform population of particles Both bands give typical virus nucleoprotein spectra, and the nitrogen/phosphorus ratios suggest that both types of particle have the same

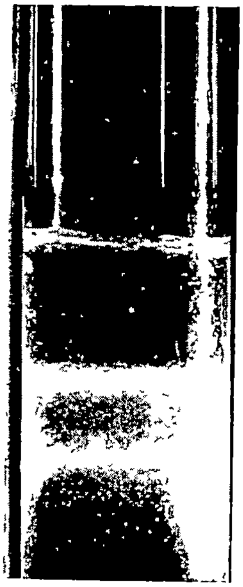

Fig. 1. Fractionation of turnip yellow mosaic virus nucleoprotein in a dense cæsium chloride solution. Of the two nucleoprotein bands appearing in the photograph, the upper (B_1) is infectious, while the lower (B_2) is non-infectious. 4 mgm. of a virus preparation in 0.15 ml. of water was layered over 3.5 ml. of a cæsium chloride solution (density = 1.41). The tube was photographed after 220 min. centrifugation at 32,000 r.p.m. in the Spinco No. 39*S* rotor

content of ribonucleic acid. Solutions of the B_1 and B_2 components equalized with respect to optical density at 260 mμ were tested for infectivity by inoculation to half-leaves of chinese cabbage. The infectivity of the B_2 component compared with B_1 from once-sedimented bands ranged in different experiments from 25 to 6 per cent.

On three times sedimented bands the B_2 material had only 3 per cent the infectivity of B_1. Thus the B_2 band is very probably completely non-infectious. However, to test the possibility that B_1 and B_2 were two different strains of the virus of differing infectivity multiplying together in the plant, four single-lesion isolates were made from plants infected with virus from each band. The isolates were multiplied in chinese cabbage. No symptom differences were observed. Virus isolated by an initial high-speed centrifugation followed by one ammonium sulphate precipitation from each isolate gave a similar band pattern in all cases. The B_2 band was present in about 1/20 the amount of the B_1 band. That virus strains were not involved was confirmed by the production of the B_1 and B_2 bands from a 'necrotic' strain of the virus which is biologically distinct from the type strain.

The B_1 and B_2 bands appear in similar proportions in virus prepared from the same plant material, either by the alcohol–ammonium sulphate procedure, or by differential centrifugation alone. It therefore seems unlikely that either of these bands is an artefact of the procedure used to isolate the virus.

However, in virus material isolated by centrifugation only, a third more slowly moving band (B_0) appears following sedimentation in cæsium chloride. This band is not visible in most ammonium sulphate preparations, and can be largely removed from virus prepared by centrifugation by one ammonium sulphate precipitation. The fact that band B_0 sediments into a cæsium chloride solution of $D = 1.40$ suggests that it must contain some ribonucleic acid. The ultra-violet absorption spectrum and the nitrogen/phosphorus ratio show that the material in the B_0 band contains a lower proportion of ribonucleic acid than the B_1 component and its infectivity is substantially less. However, the B_0 material has not yet been obtained sufficiently free from contamination with B_1 for definitive chemical analysis or infectivity tests.

A detailed study of the serological behaviour of these nucleoprotein components has not yet been made. However, all three give similar virus precipitation end-points (based on the optical density of the solution at 260 mμ) when tested with an antiserum prepared against unfractionated turnip yellow mosaic virus.

The experiments described above suggest that these nucleoprotein components are not artefacts of the purification or isolation procedures, although it may be very difficult to prove beyond doubt that they exist as such in the plant. The ability to fractionate a virus nucleoprotein preparation into infectious and non-infectious classes of particle should be useful for more detailed studies on the inactivation of the virus by various agents. The fact that turnip yellow mosaic virus nucleoprotein as usually prepared is not homogeneous may be particularly relevant for structural studies on the virus, for example, for end-group assays on the ribonucleic acid, where homogeneity of the starting material is an essential prerequisite.

This work was supported in part by a grant from the Rockefeller Foundation.

[1] Markham, R., and Smith, K. M., *Parasitol.*, 39, 330 (1949).

[2] Matthews, R. E. F., *Virology*, 5, 192 (1958).

[3] Markham, R., *Disc. Farad. Soc.*, No. 11, 221 (1951).

[4] Meselson, M., Stahl, F. W., and Vinograd, J., *Proc. U.S. Nat. Acad. Sci.*, 43, 581 (1957).

[5] Meselson, M., and Stahl, F. W., *Proc. U.S. Nat. Acad. Sci.*, 44, 671 (1958).

NITRATE REDUCTION BY AQUEOUS EXTRACTS OF EXCISED TOMATO ROOTS

By C. S. VAIDYANATHAN and Prof. H. E. STREET

Department of Botany, University College of Swansea

EXCISED tomato roots are normally supplied their nitrogen as nitrate (45 mgm. N/l.) in a medium of *p*H 4.5–4.8[1]. By substituting ferric ethylenediamine tetraacetate for the ferric sulphate of White's medium, active growth in nitrate occurs over the *p*H-range 4.0–7.2 and in ammonium (4.5 mgm. N/l.) at *p*H 6.8 or above[2]. Nitrite (7.0 mgm. N/l.) at *p*H 6.0–6.8 and glutamine (4.8 mgm. N/l.) at *p*H 6.8 can also function as nitrogen sources for root growth. A preliminary study has now been made of the nitrate-reducing activity of aqueous extracts from excised tomato roots (Best-of-All) grown with these different nitrogen sources and in presence of 0 001 p p m molybdenum

The extracts were prepared by grinding the fresh roots with three volumes of water at 4° C followed by centrifuging at this temperature for 15 min at 600*g* 1 ml of this supernatant was added to 3 ml buffer and the completed reaction mixture adjusted to 5 ml and incubated at 20° C

Nitrite was determined by the sulphanilamide-N-(1-naphthyl)-ethylenediamine hydrochloride method[3], hydroxylamine and hyponitrite by the Czaky modification of Blom's procedure[4] and ammonia by the Conway microdiffusion technique in conjunction with the phenol–hypochlorite method[5] The formation of nitrite from nitrate could be studied since nitrate reduction was not stimulated by addition of manganese whereas reduction beyond nitrite proceeded only very slowly in its absence

Extracts from nitrate-grown roots, in presence of 0 2 *M* orthophosphate buffer (*p*H 7 0), did not reduce nitrate (50 μmoles potassium nitrate) to nitrite in absence of added co-factors or in presence of combinations of molybdenum (0 1 μmole), reduced diphosphopyridine nucleotide (0 3 μmole) and flavin mononucleotide (0 5 μmole) However, the further addition of aldehyde-free ethanol (3 5 m moles), lactate (0 35 m mole), succinate (3 0 μmoles) or glutamate (1 5 μmoles) led to the formation of 5–7 mμmoles nitrite in 3 hr The necessity for these additions and the fact that a further small enhancement of nitrite formation followed the simultaneous addition of 0 8 μmole nicotinamide[7] suggest the presence in the root extracts of a diphosphopyridine nucleotide oxidase[6] By contrast, similarly prepared extracts from 15-day-old tomato seedlings showed the nitrate reductase activity (5 3 mμmoles nitrite/ 3 hr) without the addition of any dehydrogenase substrate

The formation of nitrite by the extract of excised roots in the presence of molybdenum, diphosphopyridine nucleotide, flavin mononucleotide and ethanol began to deviate from linearity within 2 hr although the nitrite content continued to increase for at least 10 hr Activity could be detected over the *p*H range 5 7–8 0 with optimum activity at *p*H 6 5–7 0[8] When tested at 10^{-3} *M*, potassium cyanide caused 90 per cent, and copper sulphate 50 per cent, inhibition of activity , diethyldithiocarbamate, *o*-phenanthroline and 8-hydroxyquinoline were inactive as inhibitors at this concentration 10^{-3} *M* sodium fluoride was slightly stimulatory Omission of molybdenum caused up to 20 per cent reduction in activity

Extracts from excised roots grown for 15 days with ammonium or glutamine as nitrogen sources had barely detectable nitrate reductase activity, whereas, in a simultaneous test, extracts from nitrate- and nitrite-grown roots formed 5 2 and 4 5 mμmoles nitrite, respectively, in 2 hr Similar adaptive formation of the reductase has been reported from work with rice seedlings[9] and wheat embryos[10] It is an essential part of future work to study this adaptive formation in excised roots over the short time periods which have been used in work with leaf fragments[11]

Verhoeven[12] has emphasized that at least three different types of nitrate-reducing systems are known and therefore, in encountering lack of nitrate reduction by excised root extracts in presence of added molybdenum, diphosphopyridine nucleotide and flavin mononucleotide, we tested a number of other combinations of possible electron donors and activating metals This led to the detection of an enzymic reduction of nitrate to nitrite for which ascorbic acid and ferrous iron are essential co-factors Ascorbic acid causes a non-enzymic destruction of nitrite at the high acidity of the sulphanilamide reagent used for the nitrite determination[13] This was reduced by the presence in the reaction mixture of iron and root extract Higher values for nitrite were obtained by addition to the reaction mixture of 100 mgm 'Norit' carbon[14] prior to the nitrite determination, despite the known adsorption of nitrite by this reagent[15]

The standard reaction mixture used in assaying the activity of the ascorbic acid–ferrous iron enzyme system contained, in 5 ml 3 ml 0 2 *M* phosphate buffer (*p*H 7 2), ascorbic acid (1 1 μmoles) ferrous sulphate (0 7 μmole), molybdenum (0 1 μmole), 50 μmoles potassium nitrate and 1 ml root extract Root extracts prepared on separate occasions differed in activity , nitrite formation in 2 hr at 20° C ranged from 3 5 to 8 1 mμmoles Omission of molybdenum reduced activity by up to 15 per cent No activity could be detected with boiled extract or when either iron or ascorbate was omitted, except that ascorbate alone had low activity in presence of 0 3 ml saturated solution of sodium fluoride, possibly due to fluoride inhibition of the dissimilation of endogenous electron donors[16] Nitrite formation did not occur in presence of root extract, buffer and homocysteine, but this latter substance alone among those tested significantly enhanced activity in presence of ascorbate (for example, 0 15 μmole homocysteine raised the nitrite production in 2 hr from 3 7 to 6 5 μmoles)

No results have yet been obtained on which to assess the *in vivo* significance of this ascorbic acid–iron activated system Study of its activity in reduction below the level of nitrite was precluded by the demonstration that ascorbate + iron caused a non-enzymatic destruction of hydroxylamine without formation of detectable quantities of nitrite or ammonium

Using a reaction mixture containing diphosphopyridine nucleotide, flavin mononucleotide (or 0 65 μmole glutathione), 1 5 μmole nitrite, 0 1 μmole manganese and 3 ml 0 2 *M* pyrophosphate buffer (*p*H 7 5) extracts from nitrate- or nitrite-grown roots caused complete disappearance of nitrite in less than 3 hr Only very low activity occurred in absence of added manganese[17] Very little or no ammonium formation accompanied disappearance of nitrite, and the main reduction product appeared to be hyponitrite since it could be oxidized back to nitrite by iodine, and hydroxylamine could not be detected by the *o*-phenanthroline method[18] Extracts prepared from roots grown with ammonium or glutamine as nitrogen sources showed barely detectable nitrite reductase activity

Extracts from nitrate-grown excised roots formed ammonium from nitrite (1 5 μmoles), hyponitrite[14] (1 0 μmole) or hydroxylamine (4 3 μmoles) when both lactate (0 35 m mole), succinate (3 0 μmoles) or formate (6 1 μmoles) and nicotinamide (0 8 μmole) were added to the reaction mixture Only about 30 mμmoles ammonia arose during the complete destruction of the added nitrite Hyponitrite destruction proceeded slowly and extension of the incubation period to 10 hr was required to obtain 20 mμmoles ammonium Hydroxylamine disappeared completely within the 2 hr incubation period but only 30–35 per cent of the nitrogen was recovered as ammonium, suggesting the possible formation of oxime-like compounds

Excised tomato root extracts in presence of added diphosphopyridine nucleotide and flavin mononucleotide can effect reduction of nitrate, nitrite, hyponitrite and hydroxylamino, in agreement with results for *Neurospora crassa*[17,18] The reduction steps beyond nitrite are activated by manganese In this chain the hyponitrite reduction step appears to be rate limiting Roots grown upon ammonium or glutamine have very low nitrate- and nitrite-reducing activities as compared with nitrate- and nitrite-grown roots A thermo-labile system for which ascorbate and iron are co-factors and which *in vitro* effects nitrate reduction is also present

Acknowledgment is made to the University College of Swansea for a research fellowship and to the Indian Institute of Science for the leave of absence which enabled one of us (C S V) to participate in this work

[1] White, P R , "A Handbook of Plant Tissue Culture" (Lancaster, 1943)

[2] Sheat, D E G , Fletcher, B H , and Street, H E , *New Phytol* (in the press)

[3] Snell, F D , and Snell, C T , "Colorimetric Methods of Analysis" (New York, 1949)

[4] Czaky, T Z , *Acta Chem Scandinavica*, 2, 450 (1948)

[5] Cuny, L , *J Pharm Chem* , 3, 150 (1926)

[6] Humphreys, T E , and Conn, E E , *Arch Biochem Biophys* , 60, 226 (1956)

[7] Zatman, L J , Kaplan, N O , and Colowick, S P , *J Biol Chem* , 200, 197 (1953)

[8] Evans, H J , and Nason, A , *Plant Physiol* , 28, 233 (1953) Nicholas, D J D , and Nason, A *J Biol Chem* , 207, 353 (1954)

[9] Tang, P S , and Wu, H Y , *Nature*, 179, 1355 (1957)

[10] Ryven, A H G C , *Austral J Biol Sci* , 11, 142 (1948)

[11] Hewitt, E J , and Afridi, M M R K , *Nature*, 183, 57 (1959)

[12] Verhoeven, W , Symposium on Inorganic Nitrogen Nutrition, ed McElroy, W D , and Glass, B , 61–86 (Baltimore, 1956)

[13] Evans, H J , and McAuliffe, C , Symposium on Inorganic Nitrogen Nutrition, ed McElroy, W D , and Glass, B , 192 (Baltimore, 1956)

[14] Fox, F W , and Levy, L , *Biochem J* , 30, 208 (1936)

[15] Nicholas, D J D , Medina, A , and Jones, O T G , *Biochim Biophys Acta* (in the press)

[16] Morton, A G , *J Exp Bot* , 7, 97 (1956)

[17] Nicholas, D J D , 13th S E B Symposium on "Utilization of Nitrogen and its Compounds", 1 (Camb Univ Press, 1959)

[18] Medina, A , and Nicholas, D J D , *Nature*, 179, 533 (1957) *Biochim Biophys Acta*, 25, 138 (1957)

A NEW APPROACH TO THE DATING OF THE DEAD SEA SCROLLS

By Prof D BURTON, M.B E., J B. POOLE and Dr R REED

Department of Leather Industries, The University, Leeds, 2

SINCE their discovery some twelve years ago, the Dead Sea scrolls have attracted considerable interest for the light they may throw upon historical Judaism and Christianity The scrolls, mostly written upon materials derived from animal skin, were found in a number of caves at the edge of the Judaean plateau, a dry and largely infertile region about a mile from the western shore of the Dead Sea The richest collection of manuscripts came from Cave 4, a mere stone's throw from the ruins of a settlement known as Khirbet Qumran

It was early considered that a connexion might exist between the settlement and the scrolls , thus for a number of seasons archæologists excavated the site[1] The oldest levels were of Israelite occupation and dated from the eighth–seventh centuries B C The major part of the finds, however, pointed to an establishment which was probably built in the reign of John Hyrcanus (135–104 B C) and which was elaborated up to 31 B C , when it is thought to have been abandoned following a severe earthquake in Judaea The site lay deserted until the time of Herod Archelaus (4 B C –A D 6), when it was reoccupied by the previous settlers until it was finally destroyed by Roman solders in A D 68 during the first Jewish revolt

Some controversy still surrounds the identification of the settlers, but the majority view[2] is that they were either the Jewish religious sect called the Essenes or another Jewish group having much in common with the Essenes It is generally believed that the scrolls were the property of the settlers, and thus the archæological datings of the occupation of Qumran constitute criteria for dating the manuscripts

The large number of scrolls which have been discovered has also enabled palæographers to trace with greater certainty the evolution of Hebrew script and thus, independently, to date the copying of the manuscripts Briefly, the scrolls cover the period from the late third century B C to the second half of the first century A D , while the manuscripts regarded as peculiar to their owners (for example, the Manual of Discipline) are considered to have first appeared in the middle of the second century B C (ref 3) This latter date corresponds with the time when the Dead Sea community first segregated themselves from their fellow Jews, and also is in substantial agreement with the earliest settlement levels at Qumran However, these majority views have not been universally accepted, and throughout Del Medico[4] has maintained that no direct connexion between the scrolls and the settlement existed Del Medico considers that the scroll caves are deposits (*genizoth*) of books either worn out through extensive use or unacceptable in character to the Jewish authorities If this view is correct, the date of the final abandonment of the settlement obviously could not be used as a guide for dating the scrolls Independently, Sukenik[5] had come to a similar conclusion Furthermore, Driver[6], Teicher[7] and Zeitlin[8], while not acepting the *genizoth* hypothesis, all favour dates later by as much as several centuries than those indicated above

Thus a need still exists for additional methods of dating the scrolls and preferably for those free from the subjective element inherent in the palæographic approach and involving the examination of the chemical and physical nature of the actual scroll materials

No such dating tests on the scrolls themselves have hitherto been made. Linen from Cave 1 and palm wood from the settlement ruins have been dated by the radioactive carbon technique and gave median dates of A.D. 33, with a standard deviation of 200 years for the linen[9] and of 7 B.C. and A.D. 18, each with a standard deviation of 80 years, for the palm wood samples[10]. However, the exactness of this dating technique for archæological purposes is limited and the method can give at best only general confirmation of dates established by other means[11].

The fact that many of the scrolls are made from animal skins, the major fibrous component of which is collagen, affords the possibility of an independent method of dating by measuring the shrinkage temperature of the fragments. Unpublished work from this laboratory has shown that the scrolls are parchments, made mainly from the skins of sheep and of goats. Parchment is made from animal skins which have been unhaired and then allowed to dry under tension, usually by stretching on a wooden frame. The resulting material is durable and needs no further chemical treatment, though often, for writing purposes, the surface is made smooth by mechanical means. Thus the making of parchment is quite distinct from that of leather, where the unhaired skin (pelt) is stabilized by treating it chemically with a tanning agent. Skins processed as parchment may last for very long periods provided they are kept dry. Indeed, this is the reason why the Dead Sea scrolls are still in existence. Any degenerative changes occurring in the collagen fibres present in dry parchments are thus likely to be due mainly to the passage of time. Moreover, these changes should be reflected in a lowering of the shrinkage temperature of the collagen fibres. Accordingly, the shrinkage temperatures of a number of scroll fragments were compared with those of other parchment-like materials of known age, in an attempt to establish a correlation between age and shrinkage temperature. The materials studied were:

Group *A*. English parchments covering the period 1193–1955 A.D. Supplied by the Public Records Office, the Chapter Library of Canterbury Cathedral, Dr. M. L. Ryder, Wool Industries Research Association, Leeds, 6, and Mr. T. H. Gardner, of Ampthill, Beds.

Group *B*. Parchments from the Wady Murabba'at caves, dating from the second Jewish revolt, A.D. 132–135.

Group *C*. Scroll fragments from Cave 4, Qumran. These and the Murabba'at fragments were supplied by the Department of Antiquities, Hashemite Kingdom of Jordan, and by Mr. J. M. Allegro, University of Manchester.

Group *D*. Egyptian Aramaic letter fragments of the fifth century B.C., supplied by the Bodleian Library, Oxford.

Group *E*. Egyptian raw hide axe-hafting, c. 1300 B.C., supplied by the Department of Egyptian Antiquities, British Museum.

The shrinkage temperatures were determined by the method of Borasky and Nutting[12] as slightly modified by Gill[13]. Small samples of the materials were rehydrated for 1 hr. in distilled water and small fibres teased from them, before mounting (between circular cover slips) on the heating stage of the microscope. Heat was applied at a constant rate (2 deg. C./min.) and, so far as possible, fibres of similar size were used. The shrinkage temperature was taken as being that at which the fibre first began to shrink.

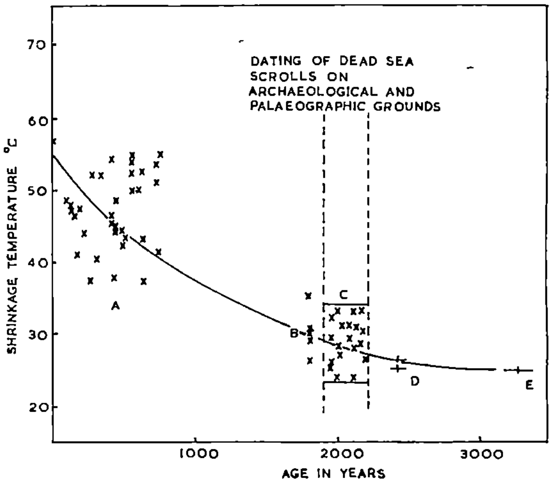

Fig. 1

Usually the mean of three determinations was taken for each material, and the results are shown in Fig. 1.

As regards their shrinkage temperatures, the scroll fragments lie closer to the older samples in groups *B*, *D* and *E* than to the relatively modern parchments (group *A*), which all show higher values. Hence it is likely that the scroll fragments are indeed old and that they are slightly older than the Murabba'at samples, the age of which is well authenticated. Moreover, it is unlikely that the scroll material dates from medieval times, as Zeitlin[8] has suggested. The present findings on the date of the scrolls are thus in general agreement with the assessments based on archæological, palæographic and radioactive-carbon studies. One could be more certain of the usefulness of shrinkage temperature as a guide to age if more parchments older than A.D. 1200 were available for study; but such samples are very difficult to obtain. It should be emphasized that this method of dating necessarily only gives a general guide to the date at which the scroll materials themselves were processed from animal skins. It throws no direct light on the dates at which the scrolls were copied and deposited in the caves.

We wish to thank the Department of Scientific and Industrial Research for providing a special grant for this work; also those people who have kindly supplied us with the various samples.

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[1] de Vaux, R., *Rev. Biblique*, **60**, 33 (1953); **61**, 206 (1954); **63**, 533 (1956).

[2] Cross, F. M., "The Ancient Library of Qumran and Modern Biblical Studies" (Doubleday and Co., Garden City, New York, 1958). Fritsch, C. T., "The Qumran Community" (Macmillan, New York, 1956). Pfeiffer, C. F., "The Dead Sea Scrolls" (Baker Book House, Grand Rapids, Michigan, 1957).

[3] Cross, F. M., "The Ancient Library of Qumran and Modern Biblical Studies", 87 (Doubleday and Co., Garden City, New York, 1958).

[4] Del Medico, H. E., "The Riddle of the Scrolls", trans. H. Garner (Burke, London, 1958).

[5] Sukenik, E. L., "The Dead Sea Scrolls of the Hebrew University" (Magnes Press, Hebrew Univ., Jerusalem, 1955).

[6] Driver, G. R., "The Hebrew Scrolls from the Neighbourhood of Jericho and the Dead Sea" (Friends of Dr. William's Library, Fourth Lecture, Oxford Univ. Press, 1951).

[7] Teicher, J. L., *J. Jewish Studies*, **2**, No. 2, 67 (1951).

[8] Zeitlin, S., *Jewish Quart. Rev.*, N.S., **39** (1948–49) *et seq.* (*passim*).

[9] Sellers, O. R., *Biblical Archaeologist*, **14**, 29 (1951).

[10] Zeuner, F. E., "Dating the Past", 344, 4th edit. (Methuen, London, 1958).

[11] Vaughan, D. E., *New Scientist*, **3**, No. 75, 32 (1958).

[12] Borasky, R., and Nutting, G. C., *J. Amer. Leather Chem. Assoc.*, **44**, 830 (1949).

[13] Gill, A., Ph.D. thesis, Univ. of Leeds (1958).

FORTHCOMING EVENTS

(*Meeting marked with an asterisk * is open to the public*)

Monday, October 12

Institution of Electrical Engineers (at Savoy Place, London, W C 2), at 5 30 p m —Discussion on "Is the Present Pace of Electrical Progress Good for the Community ?"

Society of Chemical Industry, Surface Activity Group (at 14 Belgrave Square, London, S W 1), at 5 30 p m —Dr Chas M Blair "The Resolution of Petroleum Emulsion"

University of London (in the Anatomy Lecture Theatre, University College, Gower Street, London, W C 1), at 5 30 p m —Prof C D O'Malley (University of California Medical School) First of three lectures on "Andreas Vesalius—The Development of a Scientist" (Further lectures on October 14 and 15)*

Bee Research Association (in the Meeting Room of the Zoological Society of London, Regent's Park, London, N W 1), at 6 30 p m —Dr F G Smith "Bees and Beekeeping in the Tropics", illustrated by a colour film "Tanganyika Beeswax" 8 p m —Prof G F Townsend "The Activity of Royal Jelly Against Leukaemia and Ascitic Tumours"

Royal Institute of Chemistry, London Section (joint meeting with the Ewell County Technical College Faraday Society, at the Ewell County Technical College, Reigate Road, Ewell, Surrey), at 7 p m —Dr A T James "Gas Phase Chromatography"

Tuesday, October 13

Physical Society, Low Temperature Group (at the Royal Institution, Albemarle Street, London, W 1), at 4 p m —Dr H London "Superfluid Helium" (First Simon Memorial Lecture)

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W C 2), at 5 30 p m —Prof A Tustin "The Relationship of Physical Mechanisms to Psychological Processes" (Chairman's Address)

Society of Chemical Industry, Food Group (joint meeting with the Chemical Engineering Group, at 14 Belgrave Square, London, S W 1), at 6 15 p m —Mr G C Eddie and Mr S Forbes Pearson "Engineering Aspects of Recent Research Projects in the Preservation of Fish"

British Association for the Advancement of Science in association with Granada TV Network (at the Guildhall, London, E C 2), at 8 30 p m —Sir Edward Appleton, F R S First of the Inaugural Series of The Granada Lectures on the theme of "Communication in the Modern World"

Wednesday, October 14

British Coal Utilisation Research Association (at the Institution of Civil Engineers, Great George Street, London, S W 1), at 5 30 p m —Sir Eric Rideal, F R S "Coal—a Colloid and a Chemical" (Eighth Coal Science Lecture)

Institution of Electrical Engineers, Education Discussion Circle (at Savoy Place, London, W C 2), at 6 p m —Discussion on "Graduate Training in Industry", opened by Mr W H Taylor

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S W 1), at 6 p m —Mr H Desmond Carter "The Engineer, Life and Diesel Engines" (Presidential Address)

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S W 1), at 6 p m —Mr K H R Wright "Fretting Corrosion"

Thursday, October 15

Society of Chemical Industry, Corrosion Group (joint meeting with the Iron and Steel Institute, at 14 Belgrave Square, London, S W 1), at 2 p m —Discussion of the 6th Report of the B I S R A Corrosion Committee

Institution of Mining and Metallurgy (at the Geological Society of London, Burlington House, Piccadilly, London, W 1), at 5 p m —Scientific Papers

Linnean Society of London (at Burlington House, Piccadilly, London, W 1), at 5 p m —Dr C R Metcalfe "A Botanical Visit to the West Indies", Dr Norman K B Robson "Iter Zambesiacum 1958–1959"

Institution of Electrical Engineers, Utilization Section (at Savoy Place, London, W C 2), at 5 30 p m —Mr T E Houghton "The Electrical Engineer and the Heavy Chemical Industry" (Chairman's Address)

Illuminating Engineering Society (at the Royal Institution, Albemarle Street, London, W 1), at 6 p m —Sir Lawrence Bragg, F R S "The Nature of Light" (Golden Jubilee Lecture)

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S W 1), at 6 p m —Dr E D Tingle and Mr N Wright "An Investigation of the Weathering of Road Tar in Open Textured Surfacing", Dr J R Dewhurst "An Investigation of the Setting of Road Tar in Surface Dressing"

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W 1), at 7 30 p m —Sir William MacArthur, K C B , D S O "The Identification of Some Pestilences of the Past" (Presidential Address)

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned

Scientific Assistant (with a biological degree, the ability to write correct English, and preferably some knowledge of foreign languages) for work which includes the abstracting and reviewing of biological literature—The Director, Commonwealth Bureau of Plant Breeding and Genetics, School of Agriculture, Cambridge (October 15)

Scientific Officer (male, with a first- or second-class honours degree in physics or chemistry, and preferably some experience of polymers or biological systems, or ionizing radiation), at the Royal Military College of Science, Shrivenham, Wiltshire, for a two or three years' programme of fundamental research (of an academic character and intended for publication) on effects of high energy radiation on polymers in solutions, and an Assistant Experimental Officer or Assistant (Scientific) (with a qualification in physics or chemistry at G C E 'A" level, or alternatively some laboratory experience) for work on the same programme—Technical and Scientific Register (K), Ministry of Labour and National Service, 26 King Street, London, S W 1, quoting A 410/9A (October 19)

Gordon Craig Fellow (graduate in medicine) in Urology in the Department of Surgery at the University of Sydney and in the Department of Urology at the Royal Prince Alfred Hospital—The Professor of Surgery, The University, Sydney, Australia (October 23)

Lecturer or Assistant Lecturer in the Department of Education—The Registrar, The University, Leeds 2 (October 24)

University Tutor or Assistant Lecturer in Microbiology—The Secretary, The Queen s University, Belfast (October 30)

Lecturer or Assistant Lecturer in Pure Mathematics—The Registrar, The University, Leeds 2 (October 31)

Lecturer (with an honours degree of a British university and appropriate teaching experience) in Philosophy at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Hong Kong, November 6)

Lecturer (preferably with qualifications in stratigraphical and structural geology) in Geology at the University of Sydney, Australia —The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, November 7)

Scientific Officer (with a good honours degree, and preferably with postgraduate experience and an interest in soil zoology) in the Entomology Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (November 14)

Senior Demonstrator (with experience in physical chemistry), and a Laboratory Technician (with experience in physical chemistry) in the Department of Chemistry, University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (November 14)

Lecturer in Pathology—The Secretary, The University, Edinburgh (November 15)

Lecturer (preferably with special qualifications in biometry or biochemistry and physiology or mycology and plant pathology) in Botany at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, November 30)

Mycologist (with a good honours degree in botany with mycology as a special subject, and a knowledge of the more fundamental aspects of animal and human mycoses), at the Commonwealth Mycological Institute, Kew—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (November 30)

Senior Research Fellow (with a postgraduate degree or research experience in the biochemistry or immunology of parasitic infections) in Immunology—The Registrar, University of Queensland, St Lucia, Brisbane, Queensland, Australia (December 1)

Entomologist (with a good honours degree in zoology, with at least two years' postgraduate experience or training in agricultural entomology) in the Department of Agriculture, Nyasaland, to control crop pests—The Department of Recruitment, Colonial Office, London, S W 1, quoting BCD 63/4/016

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Iron and Steel Institute Sixth Report of the Corrosion Committee Compiled by Dr J C Hudson (Special Report No 66) Pp x+217 (London Iron and Steel Institute, 1959) 63*s* [77

Anti-Locust Bulletin No 36 Reproduction in the Red Locust (*Nomadacris septemfasciata* Serville) in the Laboratory By Dr Maud J Norris Pp ii+46 (London Anti-Locust Research Centre, 1959) 7*s* 6*d* [77

Relations Between Water and Soil By T J Marshall (Technical Communication No 50 of the Commonwealth Bureau of Soils, Harpenden) Pp vii+91 (Farnham Royal Commonwealth Agricultural Bureaux, 1959) 20*s* [77

Department of Scientific and Industrial Research Torry Research Station Torry Technical Paper No 1 The Temperature of British Fish during Distribution in Summer By Dr G H O Burgess, R M Cockburn, Dr C L Cutting and W B Robb Pp iv+55 (Edinburgh H M Stationery Office, 1959) 3*s* 6*d* [77

British Empire Cancer Campaign Thirty-sixth Annual Report covering the year 1958 Part 1 The Chairman's Statement and the Accounts Pp ii+43 Part 2 The Scientific Report of the Researches undertaken by the Central Organisation and Its Autonomous Councils in the United Kingdom, and by some of Its Affiliated Organisations Overseas Pp. lviii+636 (London British Empire Cancer Campaign, 1959) [77

Lister Institute of Preventive Medicine Report of the Governing Body, 1959 Pp 34 (London Lister Institute of Preventive Medicine, 1959) [77

The Journal of Mechanical Engineering Science, Vol 1, No 1 (June 1959) Pp ii+91 Published quarterly Annual subscription rates (4 issues) Members 30*s* Non-members 60*s* Single copies Members 10*s* Non-members 20*s* (London Institution of Mechanical Engineers, 1959) [77

Greenwich Observations in Astronomy, Magnetism and Meteorology made at the Royal Observatory, Greenwich , the Royal Greenwich Observatory, Herstmonceux , and the Royal Greenwich Observatory, Abinger, in the year 1950, under the direction of Sir Harold Spencer Jones Pp xxx+322 (13 plates) (London H M Stationery Office, 1959) 100*s* net [77

Colonial Development Corporation Annual Report and Statement of Accounts for year to 31 12 58 Pp v+69 (London H M Stationery Office, 1959) 4*s* 6*d* net [107

University of Reading National Institute for Research in Dairying Report 1958. Pp 154 (Shinfield National Institute for Research in Dairying, 1959) [107

Thirty-ninth Annual Report of the Board of the Institute of Physics Pp 18 (London Institute of Physics, 1959) [107

Digest of Soviet Technology, No 2 (May, 1959) Edited by Dr M M Barash and Dr P L B Oxley (Express Information on recent Technological Developments in the Soviet Union and Eastern Europe) Pp 49 Annual subscription rate (12 issues) £6 6*s* 0*d* (post free) (Kirkham, Preston Engineering Information Services, 1959) [107

Other Countries

University of California Publications in Geological Sciences Vol 32, No 6 Geology of the La Venta Badlands, Colombia, South America By Robert W Fields Pp 405–444+plates 37–40 (Berkeley and Los Angeles University of California Press, London Cambridge University Press, 1959) 1 dollar [77

Army Map Service, Washington Technical Report No 24 Statistical and Harmonic Analysis of Gravity (Project No MO–011, March, 1959) Pp iv+142 (Washington, D C . Army Map Service, 6500 Brooks Lane, 1959) [77

Museum of Applied Science of Victoria Report of Activities for the year ended 30th June 1958 Pp 27 (Melbourne Museum of Applied Science of Victoria, 1959) [77

Bulletin of the American Museum of Natural History Vol 117, Article 4 Organism Communities and Bottom Facies, Great Bahama Bank By Norman D Newell, John Imbrie, Edward G Purdy, and David L Thurber Pp 177–228+plates 58–69 (New York American Museum of Natural History, 1959) 1 75 dollars [77

California Academy of Sciences Proceedings Vol 29, No 13 (May 29, 1959) From Pipefish to Seahorse—a Study of Phylogenetic Relationships By Earl S Herald Pp 465–473 Vol 29, No 14 (May 29, 1959) A Review of the Snakes of the Genus *Pseudorabdion* with remarks on the status of the Genera *Agrophis* and *Typhlogeophis* (Serpentes Colubridae) By Alan E Leviton and Walter C Brown Pp 475–508 Vol 29, No 15 (May 29, 1959) Behavior and Reactions of the Pacific Sardine, *Sardinops caerulea* (Girard), Under the Influence of White and Colored Lights and Darkness By Anatole S Loukaskin and Norman Grant Pp 509–548 Annual Report for the year ending June 30, 1958, with a condensed Report for the years since 1954 Pp 48 (San Francisco California Academy of Sciences, 1959) [77

Canada Department of Northern Affairs and National Resources National Museum of Canada Bulletin No 154 (Biological Series No 53) Mammals of the Islands in the Gulf of St Lawrence By A W Cameron Pp iii+165 2 dollars Bulletin No 156 (Biological Series No 55) Plants of the Clay Belt of Northern Ontario and Quebec By W K W Baldwin Pp vi+324 (17 plates) 2 dollars Bulletin No 158 (Biological Series No 56) The Marine Algae of the Labrador Peninsula and Northwest Newfoundland—(Ecology and Distribution) By Robert T Wilce Pp iv+103 (11 plates) 1 50 dollars Bulletin No 159 (Biological Series No 57) The Mammals of Banff National Park, Alberta By A W F Banfield Pp v+53 1 dollar (Ottawa Queen's Printer, 1958) [77

Ghana Annual Report of the Forestry Department for the Calendar year 1957 Pp iv+43 (Accra Government Printer, London Crown Agents for Oversea Governments and Administrations, 1959) 5*s* [77

Smithsonian Institution Bureau of American Ethnology Bulletin No 171 The North Alaskan Eskimo—a Study in Ecology and Society By Robert F Spencer Pp vi+490+9 plates (Washington, D C Government Printing Office, 1959) 2 50 dollars [77

Republik Indonesia Kementerian Perhubungan Lembaga Meteorologi dan Geofisik Verhandelingen No 53 (1) Further Remarks on Pyrheliometric Measurements and Measurement of the Brightness of the Sky in Indonesia By J J M Reesinck and Soetrismo Hadi (2) Nightly Decrease of Relative Humidity at the Summit of Mt Tangkuban Prahu, Compared with Results of Radiosonde Observations at Djakarta By J J M Reesinck and Kho Sin Tjoen Pp 24 Verhandelingen No 54 (ı, Δ)-Curves for Bodily Seismic Waves of any Focal Depth By A R Ritsema Pp 10 Earthquakes in Indonesia 1956 Pp ii+20 (Djakarta Kementerian Perhubungan Lembaga Meteorologi dan Geofisik, 1957 and 1958) [77

Publikationer fra det Danske Meteorologiske Institut, Charlottenlund Isforholdene i de Arkriske Have 1956 (The State of the Ice in the Arctic Seas 1956) Prepared by Cmdr M V L Lorck, R D N T (Appendix to the Nautical–Meteorological Annual 1956) Pp 34+5 maps (Charlottenlund Danske Meteorologiske Institut, 1959) [77

Indian Council of Medical Research The Nutrition Research Laboratories, Coonoor, S India Annual Report for 1957–58 Pp iii+60 (Coonoor Indian Council of Medical Research, 1958) [77

Indian Council of Agricultural Research Misc Bulletin No 82 Bovine Stars of India All India Cattle Show 1955 Pp iv+29 Rs 2 37 , 4*s* Bulletin No 81 The Fungi of Delhi By B L Chona, G Lall, and N C Kakria Pp iii+43 Rs 3 50 , 5*s* 6*d* (Delhi Manager of Publications, 1957 and 1958) [77

The Carlsberg Foundation's Oceanographical Expedition Round the World 1928–30, and previous "Dana" Expeditions "Dana" Report No 48 Étude des Larves Leptocephales du Groupe *Leptocephalus lanceolatus* Strömman et Identification a la Famille des Serrivomeridae Par Marie-Louise Bauchot Pp 148+2 planches 40 Danish kr. "Dana" Report No 50 Descriptions of *Euthynnus* and *Auxis* Larvae from the Pacific and Atlantic Oceans and Adjacent Seas By Walter M Matsumoto Pp 34 10 Danish Kr (Copenhagen Andr Fred Høst & Son, 1959) [77

1° Symposium Internazionale sul Lisozima di Fleming, Milano, 3, 4, 5, Aprile 1959 Riassunti delle Relazioni e Communicazioni Pp 160+xxiv (Milano Segretaria 1° Symposium Intern sul Lisozima du Fleming, Via Modica 6, 1959) [77

Bulletin of the American Museum of Natural History Vol 117, Article 6 Studies on Social Groupings in Fishes By C M Breder, Jr Pp 393–482+plates 70–80 (New York American Museum of Natural History, 1959) 1 50 dollars [77

Skrifter fra Danmarks Fiskeri- og Havundersøgelser Nr 19 Fiskeriundersøgelser i 1958 ved Danmark, Faerøerne og Grønland Ved E Bertelsen og Paul M Hansen Pp 40 (København C A Reitzel, 1959) 3 Swedish kr [77

Metropolitan Life Insurance Company Statistical Bulletin, Vol 40 (May 1959) Marriages Decrease Again Health in Hawaii Recent Trends in Infant Mortality Injuries on the Job Pp 12 (New York Metropolitan Life Insurance Company, 1959) [77

The South African Institute for Medical Research, Johannesburg Annual Report for the year ended 31st December 1958 Pp 122 (Johannesburg South African Institute for Medical Research, 1959) [77

Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture, Bruxelles Rapport Annuel, Exercice 1958 Pp 233 (Bruxelles Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture, 1959) [77

Institut National pour l'Étude Agronomique du Congo Belge Bureau Climatologique—Communication No 17 Étude Statistique des Chutes de Crêle au Congo Belge et au Ruanda-Urundi Par Dr Franz Bultot Pp 43 (Bruxelles Institut National pour l'Étude Agronomique du Congo Belge, 1959) [77

Berichte des Deutschen Wetterdienstes, Nr 53 (Band 7) Die Stromung an Windschutzstreifen Von Heinz Kaiser Pp 36 mit 25 Abbildungen und 2 Tabellen im Text (Offenbach a M Deutschen Wetterdienstes, 1959) [77

United States Department of the Interior Geological Survey Bulletin 1028–I Geology of the Delarofand Westernmost Andreanof Islands, Aleutian Islands, Alaska By George D Fraser and H Frank Barnett Pp v+211–248+plates 27–32 Bulletin 1045–E Core Logs from Searles Lake, Bernardino County, California By David V Haines Pp iii+317+plates 5–10 2 dollars Bulletin 1052–H Dielectric Constant and Electrical Resistivity of Natural-State Cores By G V Keller and P H Licastro Pp iv+257–285 20 cents Bulletin 1073 Quaternary Geology of the Smoke Creek–Medicine Lake–Grenora Area, Montana and North Dakota By Irving J Witkind Pp v+80+plates 1–10 1 75 dollars (Washington, D C Government Printing Office, 1959) [77

United States Department of the Interior Geological Survey Water-Supply Paper 1260–F Summary of Floods in the United States during 1952 Prepared under the direction of J V B Wells Pp. v+687–713 20 cents Water-Supply Paper 1460–F Geologic Reconnaissance and Test-Well Drilling, Camp Irwin, California By Fred Kunkul and F S Riley Pp iii+233–271+plate 9 Water-Supply Paper 1460–G Ground-Water Resources of the Lower Niobrara River and Ponca Creek Basins, Nebraska and South Dakota By Thomas G Newport With a section on Chemical Quality of the Water by Robert A Krieger Pp iv+273–323+plates 10–12 Water-Supply Paper 1472 Hydrologic Budget of the Beaverdam Creek Basin, Maryland By William C Rasmussen and Gordon E Andressen Pp v+106+plates 1–10 Water-Supply Paper 1510 Surface Water Supply of the United States 1957 Part 6–B Missouri River Basin below Sioux City, Iowa Prepared under the direction of J V B Wells Pp xi+456 1 25 dollars (Washington, D C Government Printing Office, 1959) [77

United States Department of the Interior Geological Survey Professional Paper 302–B Vegetation of the Arctic Slope of Alaska By Lloyd A Spetzman (Exploration of Naval Petroleum Reserve No 4 and Adjacent Areas, Northern Alaska 1944–53—Regional Studies) Pp iii+19–58+plates 7–12 55 cents Professional Paper 305–I Core Test, Sentinal Hill Area, and Test Well, Fish Creek Area, Alaska By Florence M Robinson and Florence R Collins (Exploration of Naval Petroleum Reserve No 4, and Adjacent Areas, Northern Alaska, 1944–53 Part 5 Subsurface Geology and Engineering Data) Pp iii+485–521+plates 31–34 1 dollar Professional Paper 327 Geology and Mineral Resources of Paraguay—a Reconnaissance By Edwin B Eckel With sections on Igneous and Metamorphic Rocks by Charles Milton and Edwin B. Eckel Soils by Pedro T Sulsona Pp v+110+plates 1–3 (Washington, D C Government Printing Office, 1959) [77

Smithsonian Miscellaneous Collections Vol 137 (Whole Volume) Studies in Invertebrate Morphology (Published in Honor of Dr Robert Evans Snodgrass on the Occasion of his Eighty-fourth Birthday, July 5, 1959) Pp v+416+49 plates (Publication 4350) (Washington, D C Smithsonian Institution, 1959) [77

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Annual subscription £7/15/–, payable in advance,
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EXPANSION OF EDUCATIONAL AND TRAINING FACILITIES IN BRITAIN

WHEN moving the second reading in the House of Lords on April 28 of the Factories Bill, which amplifies and amends the Factories Act, 1937, the Earl of Dundee pointed out that it empowered the Minister, under Clause 25, to improve his advisory services by the collection of information, the investigation of problems of health, safety and welfare, including the establishment of laboratories not only for research but also, as Mr Ian MacLeod had explained in the House of Commons, for wider purposes and the dissemination of the results to industry The Bill, in fact, constituted a new departure in factory legislation, and he emphasized the constructive and co-operative aspect of the work of the factory inspectorate There are now 409 inspectors, and it is hoped to have 445 very soon , but quality and experience are regarded as more important than numbers Other innovations in the Bill, which received the Royal Assent on July 29, empower the Minister to make special regulations as to the measures to be taken in factories to reduce the risk of fire, including regulations prescribing requirements as to the internal construction of a factory and the materials to be used, and call for the provision and maintenance in every factory of appropriate and readily available means for fighting fire.

In the debate, Lord Wilmot of Selmeston remarked that the Bill is an outstanding example of Parliament at its best in the active co-operation of Government and Opposition in pursuit of a common aim Lord Stonham expressed the hope that in promoting a partnership of safety in the factories, the Government would greatly strengthen the provisions for consultation and research into safety, and suggestd that full information was a prerequisite of confidence Lord Taylor estimated that sickness and accident in industry in Britain represent a loss of £780–£1,000 million a year, mostly through minor illness and minor accident, and he stressed the importance and value of an efficient industrial health service, including such a co-operative and mobile industrial health service as had been created at Harlow The Earl of Dundee particularly welcomed this suggestion as providing a solution to the problem of making trained assistants available to the smaller type of factory

The Bill obviously strengthens the contribution which science can render to industrial health and safety On the second reading of the Bill in the House of Commons last November, the Minister of Labour and National Service emphasized the critical importance of the strength and efficiency of the factory inspectorate, and this was recognized on all sides Mr Robert Carr, however, directed attention to the way in which the growing complexity of industry has increased the difficulty of progress simply by enforcement It has become more and more impossible for a general inspectorate to possess all the technical qualifications needed to cover the whole range of industry in its area With all the help it can draw from a more or less centralized and specialist branch, to which we must look increasingly for encouragement and advice for major advances in the future, we are once again reminded of the importance of the continual expansion of education and training facilities in Britain

Three other recent debates have also stressed the importance of this factor, and particularly the need to implement the recommendations of the Carr Report on recruitment and training of young workers in industry Intervening in the debate on secondary education in the House of Lords on February 26, Lord Rochester urged that the employment of young people, and particularly their training as apprentices, should be regarded just as much a part of their education as that which they receive at school, and that before steps were taken to raise the school-leaving age further, the possibility of industry absorbing them all at any one time each year, instead of three times as at present, should be examined Lord Rochester thought that to limit intake to one occasion in the year might in practice prove a retrograde step even to the technical education of the boys, but he urged that from the point of employment the problem is much too important to be handled without the closest consultation both with the trade unions and the employers

That aspect was also stressed in a debate on the effects of automation, on a motion of Mr F Lee in the House of Commons on May 1 Mr Lee's motion, recognizing the need for British industry to keep abreast of modern production methods, and also the need to allay fears of heavy unemployment, urged an intensive study of the probable consequences of automation, and that the Government should invite industry to co-operate in introducing the necessary changes with a minimum of hardship to its employees, and in supporting the motion Mr Austen Albu emphasized the bearing of technical education Mr MacLeod, in his reply, referred to the survey which had been made by the Department of Scientific and Industrial Research in 1954, and to the general endorsement of the conclusions of the report in July 1956 by the National Joint Advisory Council A subsequent inquiry by the Board of Trade, the results of which were published in the *Board of Trade Journal* of February 1958, suggested that automation would tend to decrease the number of unskilled labourers but increase the number of skilled technicians of all kinds Firms did not expect automation to lead to any severe reduction in the size of their labour force, partly because that force would be re-deployed substantially within the factory, and partly in consequence of an increased level of activity Mr. MacLeod believes, however, that increase in apprenticeship training is the responsibility of industry, and that the Government can only indirectly stimulate that He referred to the studies of technical change which the Department of Scientific and Industrial Research is already sponsoring and thinks that this work on the social aspects of technological innovation might be better co-ordinated and given more publicity He undertook to raise this question with the National Joint Advisory Council.

In opening a debate on youth employment problems on April 30, Mr. A Robens suggested that the future of Britain is based on the development of our technical skills, and that we must take firm action to ensure that our people are highly skilled and able to make full use of the possibilities offered in electronics, nuclear power and transfer machines. Our educational programme, including the development of technical education, contemplates an output of about 20,000 scientists and technologists a year by 1970, and to make full use of the technologists some five or six technicians are required for each technologist The production of these technicians and craftsmen is regarded by Mr Robens as the key problem, and to meet the needs of the increased number of school-leavers we should be taking about 135,000 into skilled apprenticeship a year. The evidence of recent months, he asserted, is that there are insufficient vacancies for boys who have the necessary educational qualifications, and he believes that only by persuasion or legislation will industry be induced to provide the extra training places required, many of which would be surplus to present requirements He said that the trade unions have a responsibility here —in the printing trade and in the shipbuilding industry the number of apprenticeships is strictly limited.

Mr Robens advocated re-examination of the length of time required for an apprenticeship and challenged the practice of restricting entry to those leaving school at fifteen or sixteen He believes the older boy with added educational qualifications would be likely to acquire his craft skill more rapidly, and further, that full employment could not be guaranteed on the basis of an inevitable job Mr Robens suggested that since industry could not do this on its own, the Ministry of Labour should assist by making use of redundant Royal Ordnance factories or Ministry of Supply factories, so as to meet the needs of the small firms for training apprentices Something more was required than had been recommended by the Carr Committee

The Parliamentary Secretary to the Ministry of Labour and National Service warmly welcomed Mr Robens's speech, though he thought the prospects of employment for boys and girls depend on economic expansion and not merely on the size of the bulge, and he was not convinced that opportunities for apprenticeship are as limited as Mr Robens suggested He believes that the Government's part should be, first, to provide adequate facilities for technical education, and secondly, to shape the conditions in which industry can best play its own part The Industrial Training Council should take a most important part in developing a strong and effective leadership in industry towards expanding training opportunities in each individual industry, and the Council has, in fact, already asked both employers and trade unions to examine urgently the Carr Report The Government also proposes to make a grant of £75,000 to the Council to further the appointment of training development officers, either by the Council itself or by employers' organizations, joint industrial councils or similar bodies He was confident that the Carr Report has already had a profoundly beneficial effect on the situation

Mr Robert Carr, who also spoke, explained that the Carr Committee was influenced in its recommendations by the view that more rapid progress would be achieved by building on practice and tradition rather than by breaking completely with the present system, even if the Committee did not condone the present rigidity of much of it He believes that it is essentially in the smaller and medium-sized firms that an increase in training could take place in the skills we need, and that help with the first year's training of an apprentice is particularly desirable Pre-apprenticeship courses could be developed in technical colleges, but the development of group apprenticeship schemes requires further attention, and small and medium-sized firms could be helped by more block release in technical colleges as an alternative to day release While welcoming Mr Wood's announcement, Mr Carr said he thinks there might be a capital grant towards the establishment of joint training centres and tax remission to firms in respect of the number of their apprentices, and finally he stressed the importance of quality.

Mr A Albu, who pointed out that only between 20 and 30 per cent of school leavers receive any further training at all—and in some occupations only 2–3 per cent receive any serious training for their employment—quoted an estimate that we would need 1,300,000 skilled workers and 450,000 technicians by 1966 To provide these, about 86,000 extra apprenticeships would be needed each year, or nearly three times the present number He suggested a levy, based on the number of skilled workers employed, to enable training workshops to be established in technical colleges, and also that the Industrial Training Council should be reconstituted under an independent chairman, with a specialist and highly qualified staff Stress was laid by Miss Elaine Burton and by Miss Joan Vickers on the importance of the Youth Employment Service, and the need to see that this is properly supported, and that youth employment officers are sufficiently well paid to attract able and really qualified people to such posts

Sir Edward Boyle, who replied on the debate, said that to achieve the objectives laid down in the 1956 White Paper on Technical Education, we must achieve an average increase in the number of part-time day release students of about 40,000 a year Although in 1958 there had been a recession of

17,000 part-time day-releases, the advanced levels in technical colleges are progressing well and the colleges are also diversifying their courses and providing new types of courses for the ordinary craft apprentices and technicians The teaching force of the colleges is increasing and in 1958 reached a record total of 13,500 The technical colleges, however, cannot do their best without the active co-operation of industry, and Sir Edward stressed the need for close and regular contact between the staff at the technical college and the training officers and apprentice supervisors in the factory

It is against the background of these debates that the report of the Ministry of Education for 1958* is appropriately considered, particularly the important chapter which reviews developments in technical education since the War, and more especially progress since the White Paper on Technical Education was issued in 1956 Some further information bringing the report more up to date was given in speeches of Lord Hailsham in the House of Lords debate on February 26 and in that of Sir Edward Boyle in the House of Commons on April 27 Sir Edward Boyle pointed out that during the past four years the number of pupils per full-time teacher in primary schools has declined from 32 1 to 30 6, while the number of pupils per full-time teacher in secondary classes has only risen from 20 9 to 21 4 in spite of the movement of the bulge from primary into the secondary schools From now onwards, apart from the year of intermission in 1962, the increase in the teacher force should more than match the increase in school population, and Sir Edward Boyle anticipated that primary classes of more than forty children should be virtually eliminated by the middle 1960's, with no deterioration in staffing standards in secondary schools

From 1959 Sir Edward thinks that an annual net increase of 6,000 teachers can be assumed, as 16,000 students should complete teacher training courses in 1959 and 17,000 in 1960, and this output should be maintained, an increased number of graduates is also expected to enter the schools, and wastage is unlikely to increase More recently, on June 26, Mr Geoffrey Lloyd, the Minister of Education, said that in addition to the programme for 12,000 places announced last September, he has authorized forthwith a programme of 4,000 training college places which should be effective by 1964 Sir Edward Boyle also said that the selection of highly qualified entrants who could complete a course in two years instead of three was being considered

"Education in 1958" records that although in January 1958 there were nearly 6,840,000 children in maintained and assisted schools, the rate of increase has fallen by nearly half, the rise in the number of children older than fifteen was more than double that for the previous year Nevertheless, the percentage of senior children in over-size classes remained the same although the number of over-size senior classes was slightly larger in January 1958 The total number of students taking advanced courses at technical colleges has increased from 9,500 at the time of the White Paper to more than 11,000, and of these nearly 6,500 are enrolled in sandwich courses, compared with about 2,300 early in 1956 During 1958–59, more than 19,600 out of 23,000 students admitted to universities in England and Wales, excluding those from overseas, were receiving awards from public funds, compared with 14,000 during 1954–55

Apart from the firm expression of the Government's conviction that anything like a uniform pattern of secondary education throughout Britain would be wrong, and that instead wide experiment and flexibility in organization should be encouraged, the two chapters on further education are those of most direct interest to the scientist and technologist The first of these provides a convenient concise summary of the progress that has been achieved in technical education during the past five years, without, however distinguishing as clearly as had been done in some recent debates in Parliament between the technician and the technologist One encouraging feature is the decreasing proportion of part-time education at the advanced level In the mid-1950's, more than three-quarters of technical college students who obtained professional qualifications did so by part-time study only By the late 1960's about one-half of those qualifying each year as scientists and engineers will probably have come from a technical college and less than one-third of these will have taken part-time courses

The review refers to the shedding by the colleges of advanced technology of the less advanced work, and there is some discussion of the problem of broadening a technological course It is recognized that a concept of teaching is needed in which the mere imparting of information is replaced by a more active kindling of the student's mind and interest through the personal help and guidance of the teacher, and it is the Government's policy that the colleges of advanced technology should be staffed on a basis generous enough to enable them to provide a tutorial system throughout a diploma of technology course Apart from the great benefit to the students, this should encourage the staff to adopt teaching methods which will increasingly encourage students to work on their own and to think for themselves Of the £70 million authorized for investment in technical college building in Britain during the quinquennium ending in 1961, the colleges of advanced technology claimed about £10 million Encouraging progress is recorded in regional co-ordination at the advanced level, in co-operation between the colleges and industry and in the development of research and postgraduate studies, and to a lesser extent in the development of courses in management studies The need for residential accommodation, however, will only partly be met by the 3,000 places to be provided under the five-year programme, of which nearly 2,000 will be at the colleges of advanced technology, including about 1,000 at the entirely residential college at Loughborough Recruitment of suitable teaching staff for advanced scientific and technical courses is likely to remain a serious and urgent problem, and related to this are the conditions of service for such staff Here the improvement in the climate of opinion about advanced technological education could well be a decisive factor

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* Education in 1958 Being the Report of the Ministry of Education and Statistics for England and Wales Pp v+261 (Cmnd 777) (London H M Stationery Office, 1959) 12s net

The report stresses the distinctive functions of the colleges of advanced technology and of the universities and rightly urges that both are needed. It would be more reassuring, however, to see the distinctive functions of the technical colleges and of the colleges of technology clearly recognized, and the need to keep the supply of technicians and craftsmen in balance with the expansion in numbers of both technologists and scientists This could well prove a major weakness, and although the apprenticeship system receives notice in the report, the Carr Report is merely noted and its implications even for technical education are not discussed Lord Hailsham's speech in the House of Lords on February 26 was limited essentially to secondary education, and although he referred to the improvement of facilities for teaching science, he did not touch on this vital aspect Between 1947 and 1957 the number of advanced level passes in the General Certificate of Education rose from 10,000 to 14,000 in mathematics, from 8,000 to 15,000 in physics, and from 7,000 to 13,000 in chemistry , and since the War more than £20 million has been spent on the provision and equipment of science laboratories at new and enlarged maintained secondary schools of all kinds and £3 million has been spent in three years on independent and direct-grant schools by the Industrial Fund for the Advancement of Scientific Education in Schools

This report from the Ministry of Education, and the debates in Parliament referred to earlier, demonstrate that the Government is aware of the many problems involved in expanding technical and technological education in Britain , it is the duty of professional associations and similar bodies to impress on those concerned the importance of striking a true balance between the diverse interests involved

CONCEPTUAL FOUNDATIONS OF SCIENCE

Patterns of Discovery

An Inquiry into the Conceptual Foundations of Science By Prof Norwood Russell Hanson Pp ix+241 (Cambridge At the University Press, 1958) 30*s* net

THE general thesis of this book is that observational data become significant only when seen against a given conceptual background or *Gestalt* (p 90) The theme is worked out at various levels Thus Chapter 1 discusses interpretative activity of plain observers , Chapter 2 illustrates, through a historical discussion of the work of Galileo, Descartes and Beeckman on the problem of free fall, the influence of purely geometrical as against physical attitudes on the direction of research , and Chapter 4 emphasizes the importance of physical (as compared with purely mathematical) preconceptions in their hold on Kepler's astronomical thinking Comparatively, these are historical issues, though Prof Hanson here sometimes flirts with something more important, as when he writes that "conceiving of an hypothesis has a logic" and is not merely a matter of intuition or hunches (p 71) Of course it is not But as to "logic" , when we inquire further we are after all given no more than the tame if correct remark that the physicist's task is to find the simplest formula which will include all the known data (p 84)

Hanson's conceptualist thesis is indeed mostly intended to throw light on a number of traditional philosophical issues such as the nature of causal relations (Chapter 3 causes being interpreted as "theory-loaded" (p 54) entities) , the logical status of the laws of classical dynamics (Chapter 5 whether they are considered as definitions or as conventions or as empirically testable statements depends on "the organisation of concepts" (p 96)) , as also the question whether the Indeterminacy Principle states "merely a technical" or rather "a conceptual impossibility" (p 136 , Chapter 6) This last question, perhaps the most interesting in the light of recent discussions on the ideas of Bohm and others, does not receive much clarification, being discussed merely as a further illustration of a philosophical thesis

Altogether, though this book abounds in a wealth of illustrative studies, remarks and quotations, at the end one is left with the feeling of a somewhat hazy and impressionist picture There is a great deal of trailing of the coat , the *bête noire* being "the philosophers", who now fail to grasp the elementary facts of physical reasoning (p 88) , now "think physicists confused" about the use of law-statements (p 109) , and who are finally told that not they but men like Kepler, Galileo, Newton, Einstein and others have developed physics (p 113) Sneering was never a good substitute for argument , it is never certain who these philosophers are that so dismally misunderstand , and on the few occasions when they are named, their arguments are peculiarly misrepresented Thus some contemporary logicians are chastized for having represented physical theory either as an inductive generalization, or as a piece of pure deduction, or, again, as inverse deduction, namely, the postulation (the "thinking up") of hypotheses accounting for the facts (pp 86 ff) Armed with this logical terminology, Prof Hanson imputes to the logician the absurd doctrine that the physicist first thinks up hypotheses at random and then sees what he may perchance deduce from them (pp 71 ff) Surely it was perfectly obvious that what the logician meant was think up hypotheses in the light of the problems they are meant to solve

Disentangling the puzzles and paradoxes of the language of science is a delicate operation , the statements that emerge after due reflexion, when honestly put, are deserving perhaps of slightly more respect than a hasty misreading of the evidence might suggest Prof Hanson writes that "because of the inadequacy of philosophical discussions" of the topics dealt with in his book, he proposes to use physical theory and theorizing as "the lens through which these problems will be viewed" (p 2) One reader at least has certainly gained the impression that the method is, on the contrary, the perfectly standard one of running a definite philosophical line.

But no greater damage could be done to genuine philosophy of science than to suggest that there is an easy way to a solution of its problems , let alone that they may be settled by simply inspecting the metaphysics and the language of science

The book seems most stimulating in its discussion of some of the case-studies referred to, even though one might have wanted some explanations on occasion which would have made the matter less mystifying to the general reader (Who of these understands the theory of the hodograph ? (p 106)) It can certainly be warmly recommended as accompanying reading to more sustained studies in the subject

GERD BUCHDAHL

THE WEEVILS OF FRANCE

Faune de France, Vol. 62

Coléoptères Curculionides (Troisième Partie) Par Adolphe Hoffmann Pp ii+1209–1840 (642 figures) (Paris Editions Paul Lechevalier, 1958) n p

It is now more than forty years since the last comprehensive work on European beetles appeared The present volume in this well-known series deals with the remaining weevils occurring, or likely to occur, in France and Corsica It is issued, unusually, in a stout and durable cloth binding Keys to all groups, including sometimes the varieties of a single species, are given Each couplet usually contains several easily observed characters and the keys appear to be reliable There is a full description of each species, together with many references

The figures are even more numerous than in the earlier parts, averaging more than one per page They exhibit a variety of styles and techniques but seldom reach the standard one expects nowadays in a work of this kind Some of the figures of antennae and tarsi are particularly crude , stippling and shading are frequently used where a simple line drawing would be far more effective

The author's system of classification is rather individual and open to criticism Following Reitter (1912) he has included some twenty or so subfamilies as tribes under the name "Calandrinae" Also the Attelabidae are denied their full family rank , *Rhynchites* was even used as an example of the Phanerognathi in the introduction (Part 1) In addition a number of long-established generic names (for example, *Dorytomus*) have been sunk, though in such cases an explanation is given and the reader can form his own opinion with the aid of the references The fact that the general classification of weevils has not been studied since 1866 and that the new Code of Zoological Nomenclature has yet to appear in print reduces the weight of these criticisms Furthermore, this work is essentially a faunistic study, not primarily intended to make a fundamental contribution to anatomy or taxonomy

It is in its faunistic aspect that the value of this work lies The author has taken the greatest pains to record accurately and often in great detail both the distribution and the biology of every species as far as these are known Again many references are given Many galls, etc , and leaf-rolling techniques are illustrated

Following the main body of the text is a lengthy list of additions and corrections to the whole work, also a list of food-plants with their associated weevils and a general index

R T THOMPSON

THE INVERTEBRATES

The Invertebrates Vol 5

Smaller Coelomate Groups—Chaetognatha, Hemichordata, Pogonophora, Phoronida, Ectoprocta, Brachipoda, Sipunculida, The Coelomate Bilateria By Libbie Henrietta Hyman (McGraw-Hill Publications in the Zoological Sciences) Pp viii+783 (London McGraw-Hill Publishing Company, Ltd , 1959) 104*s* 6*d*

The fifth volume of Dr Hyman's series on animal phyla is devoted to the smaller cœlomate groups, except the Echiurida These she divides into three sections the enterocœlous cœlomates or Deuterostomia (Chaetognatha, Hemichordata and Pogonophora), the lophophorate cœlomates (Phoronida, Ectoprocta and Brachiopoda) and the protostomatous cœlomates (Sipunculida) It must have been a difficult task mastering the literature on such widely varied forms of life , the bibliography is excellent

Each chapter is arranged on the same lines as those in previous volumes—history, general characters, classification, morphology, embryology, ecology and physiology, geographical distribution and relationships, so that it is easy to find a particular section. The illustrations are good on the whole, mostly copied from original papers, but a few have deteriorated in reproduction, such as *Bathyspadella*, Fig 15*A*, and the nervous system of phoronids, Fig 87. Lettering by numbers enables the reader to test his knowledge, and this is applied uniformly throughout the book

Some phyla have been exhaustively dealt with elsewhere, such as the Hemichordata, by van der Horst , others are little known or have not been adequately treated in available books and monographs It is to the latter groups that the zoologist will gratefully turn first Here for the first time we have a clear account, largely translated from the Russian, of the new phylum Pogonophora, the beard bearers, deep-sea worm-like creatures with a heart and vascular system but no digestive canal The dredging of twenty-two species of pogonophores, chiefly from the Behring and Okhotsk seas and from the Skagerrak off Norway, is one of the most remarkable finds in modern zoological research, comparable with the discovery of *Latimeria* and *Neopilina*

More than a third of the volume is devoted to the Ectoprocta, a group which "is burdened with a large and fantastic terminology" Dr Hyman therefore has correlated the terms used for the parts of the colony with those employed in invertebrates generally For her study of the Ectoprocta she travelled to Brazil, to consult with Prof E Marcus, who had worked so extensively on that group The result is an excellent account Dr Hyman prefers to call the phylum Ectoprocta and to use Bryozoa in a popular sense only, since the latter name included the Entoprocta, which must now be removed from close association with the Ectoprocta

The chapter on Brachiopoda is also a competent piece of work, especially for the palæontologist It is strange that the name is misspelt on the dust cover and the title page

The final chapter, entitled "Retrospect", enables the author to correct a few mistakes in the earlier volumes, to add short accounts of recent work not previously known and to state her views on current trends in zoology The last she does very forcibly :

"Hemichordata *must* be removed from Chordata and made an independent phylum of invertebrates"; "The concept Gephyrea must be obliterated from zoology"; "Ctenophora are a sharply delimited group with definite characteristics that entitle them to separate phyletic rank. It is even not at all settled that they have originated from Cnidaria"; "The Entoprocta are maintained as a phylum distinct from the Ectoprocta".

The volume reaches the high standard of all McGraw-Hill publications. Its cost in Britain is certainly very high, but its value as a compilation of up-to-date knowledge is undoubted. All zoologists will wish Dr. Hyman renewed health so that she may complete the great task she has set herself, and will look forward to the next volume, which is to deal with the Mollusca.

N. B. EALES

MODERN THEORY OF THE INTEGRAL

An Introduction to the Theory of Integration

By Prof. Adriaan C. Zaanen. Pp. ix+254. (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1958.) 50s.

PROF. ZAANEN'S reason for adding to the considerable number of books surveying the field of modern integration, from the classical Lebesgue theory to the developments of Radon's extension of this theory to abstract spaces, is that such accounts generally rely either on the approach through measure theory or on the concept of the linear functional; he wishes the young analyst to be familiar with both procedures. Thus after a brief preliminary section on set theory, he defines measure over a semi-ring and builds up a more general measure by an extension procedure; then Stone's method of defining the Daniell integral as the extension of a linear functional over the class of step functions is seen to be practically a special case of the extension procedure for measure. The author gives plenty of illustrations, particularly helpful in showing how the older theory fits into the more modern, so that, for example, the extension procedure applied to the Riemann integral yields the Lebesgue integral. Fubini's theorem on the reduction of a multiple integral to repeated integrations is carefully studied, as is the tedious but important Radon-Nikodym theorem, which may be regarded as a very high-level version of the change of variable in an integral. Later chapters give some applications, such as unitary transformations in Hilbert space, and ergodic theory. Measure over a Boolean algebra is excluded, but Carathéodory's book is available; and integration over a locally compact space and the related Haar measure are omitted, since an account of the relevant topology would have substantially increased the size of the volume.

The exposition is clear and precise, provided the reader pays unremitting attention, and provided he does not neglect the exercises, an integral part of the text. "The student who omits them is like the man who, when attending an excellent dinner, wants to race through the main courses only, and (under the misapprehension that it is merely the nourishing value that counts) refuses to touch the wines and little delicacies which are offered him"; and the author is offering Montrachet, not Coca-Cola.

INTERNATIONAL CYTOLOGY

International Review of Cytology, Vol. 7

Edited by Prof. G. H. Bourne and Prof. J. F. Danielli. Pp. x+684. (New York: Academic Press, Inc., 1958.) 16 dollars.

THIS volume, issued under the auspices of the International Society for Cell Biology, is probably the most valuable and interesting of the series, of which it is the seventh. Among the well-known contributors are Don W. Fawcett, Françoise Haguenau, Johannes Rhodin, F. G. Spear and Paul Weiss. The articles by Spear on the biological effects of radiation and by Ilse Lasnitzki on carcinogens, hormones and vitamins in organ cultures are topical in view of widespread interest on the effects of atomic tests, and of cigarette smoking. Spear gives a comprehensive historical review on radiation physics, the general response of living tissues to radiation and radiation chemistry, and has cleared the ground for a new approach to this field. He quotes J. A. V. Butler: "We are at the moment in the position of a man who tries to elucidate the mechanism of a telephone exchange by throwing bricks into it and observing some of the results". Naturally, Spear's section on the possibilities of chemical protection against radiation effects is of considerable interest. A number of chemical and physical agents are claimed to have such protective action in certain cases. He lists cysteine, glutathione, BAL, thiourea, glucose and ethanol. The intimate cytological results of radiation could not be examined more than cursorily by Spear. Many years ago M. J. D. White discovered as a by-product of his work on the effects of X-rays on the maturation phase of locusts that in many cases the single sperm 'middle-piece' became double, triple or even quadruple. Recent work at the Argonne National Laboratory, by Tahmisian's group, working under the auspices of the U.S. Atomic Energy Commission, has shown that the insect 'middle-piece' arises from a number of separate bodies which normally fuse to form the 'neck body'; radiation prevents their fusion, but does not prevent their growth. Further work along these lines with electron microscopy should be fruitful.

Ilse Lasnitzki, using the watch-glass plasma-extract clot technique of Fell and Robison, has investigated the effect of carcinogenic hydrocarbons on human fœtal lung, and mouse prostate, the influence of sex hormones on embryonic development of sex organs, and the changes produced by vitamin A. Lasnitzki provides some remarkable photomicrographs of the effects of 3,4-benzopyrene from cigarette smoke, on the bronchiolar epithelium. Carcinogenic hydrocarbons and sex hormones stimulate cell division in basal cells of skin and vagina, and thus induce abnormally high proliferation.

The section by Françoise Haguenau, a distinguished member of the French School of electron microscopy, goes into the question of ergastoplasm or endoplasmic reticulum. The name ergastoplasm was coined by Garnier (1897, 1899) for the *Nebenkerne* in gland cells. His work was amplified by other members of the Nancy School of Histology, such as Prenant and Bouin. Copies of their figures occur in many of the major works on histology. Happily, Haguenau also mentions the contributions of the Japanese cytologist Sakae Saguchi in this connexion. Electron microscopists entered the field, and by about 1947 really good electron micrographs of gland cells had begun to appear, pioneer work being carried out at the American National Cancer Institute by Dalton *et al.*, and at the French Cancer Institute at Villejuif by Oberling's group. The way was then open for the excellent high-resolution studies by the Swedish workers under Sjostrand, and by the active Rockefeller group led by Porter. During this enriching period, a controversy arose on nomenclature as a result of the continued use of Porter's term 'endoplasmic reticulum', which the Americans in particular believed proper to describe the ultrastructure of the classical ergastoplasm discovered by the French. Space allowed to the reviewer does not permit further reference to this topic, but Haguenau remarks, "It has been emphasized that the general acceptance by electron microscopists of the word *ergastoplasm*, in its original context would do much to bring order to the present terminological confusion".

Don W. Fawcett writes on the structure of the mammalian sperm as determined by electron microscopy. Naturally with the higher magnification and excellent resolution of the modern electron microscope, recent authors provided with these blessings have been able to better the often pathetic past efforts of the optical microscopist in this field. Nevertheless the electron micrograph has not produced any new basic facts except possibly for recognition of the peculiar lamellation of the Golgi apparatus—yet Pollister (Vol. 6 of this series) claims that Jan Hirschler did understand that the Golgi apparatus was essentially a lamellated structure. Of great interest to-day in the structure of the metamorphosing spermatid is the neck region. Fawcett holds that the base of the flagellum is connected to the head by a segmented body that is probably a highly modified distal centriole, but the reviewer has yet to see any micrograph of this region which does not show a special neck body, centriole adjunct, archoplasm (Grassé, Carasso and Favard), etc., which is material separate from the proximal centriole. In fact, the electron microscope has shown that the head centriole is not the major attachment area of head and flagellum—there is a separate structure or packing which reaches its highest state of development in insects. There seems to be no recent evidence that the centriole divides more than once in normal spermatogenesis. It must now be admitted that the mammalian post-nuclear body and the neck body or centriole adjunct are different structures.

Paul Weiss discusses cell contact—that is, (1) contact relations between cells and their physical substrata, (2) the mutual reactions of cells on contact with one another and (3) the transmission of specific agents and influences from one cell to another by direct contact. Weiss considers a cell to be in contact with another body not only if the two surfaces are in direct apposition, but also if they are separated by a narrow space occupied by a molecular population the free mobility of which is restrained. In his usual suggestive manner, Weiss has investigated the 'bobbin' structures at cell interfaces of epidermal units, and goes on to discuss the possibility that in cancer cells undergoing metastasis there is a close relation between loss of specific surface contact on one hand and mobilization and proliferation on the other. Mobilized normal cells, after recovering co-aptive relations (for example, epithelia meeting their own kind), cease to proliferate, whereas cancer cells under comparable conditions evidently do not. Weiss omits mention of the paper by Dalton, Kahler and Lloyd (*Anat. Rec.*, 111, 1951).

Papers emanating from Sjostrand's laboratory have been marked by helpful interpretative drawings which can only be made up by close study of many micrographs. These drawings will be used gratefully by authors of histology books. Johannes Rhodin's study on the anatomy of kidney tubules is a good example of Swedish work, the diagram on page 506, Fig. 14, being excellent. The studies on kidney by Pease, Dalton, Rhodin and others can now be followed by experimental work.

Another paper from the Karolinska Institutet is by Hans Engstrom and Jan Wersall. Engstrom is a practitioner in the ear, nose and throat clinic of the University of Gothenburg, yet has managed to collaborate in this erudite study of the structure and innervation of the inner-ear sensory epithelia.

A further paper is by L. M. J. Rinaldini, of the University of Cordoba, Argentina, whose work was carried out at the Strangeways Research Laboratory, Cambridge. No doubt Rinaldini will read Weiss's article with appreciation, as the two valuable papers have certain meeting points. Rinaldini has covered a great deal of difficult ground in an interesting manner, and of all the papers here mentioned, this has needed the widest grasp of the international literature on biochemical and biophysical cytology.

The supposed hypothalamo-neurohypophysial neurosecretion has been carefully considered by J. C. Sloper, of the Charing Cross Medical School, London. The subject of neuro-secretion is one that is largely made up of doubtful histology and worse cytology. Degenerate and effete cells stain darkly in toluidine blue, iron hæmatoxylin, etc.—these are supposed in some cases to be neurosecretory, whereas to the reviewer the most convincing vertebrate nerve cell secretions are those demonstrated by electron microscopy by Palay, Van Breemen, J. D. Green and others. In the case of the sympathetic neurones of the mouse, similar fine 'secretory' bodies exist in animals a few days old, and soon disappear; older cells become packed with formed bodies which are heaped aggregations of effete mitochondria lying mainly at the axon end of the nucleus. Sloper remarks that future investigations will be facilitated by a more exact knowledge of the nature of 'neurosecretory' material, and he feels unable to equate the several categories of inclusions demonstrated by various workers.

The remainder of this volume has papers on the "Lymphocyte", by O. A. Trowell of the Radiobiological Unit at Harwell, on "Autoradiographic Studies with S^{35}-Sulphate", by D. D. Dziewiatkowski, of the Rockefeller Institute, on "Recent Advances in the Study of the Kinetochore" (centromere), by A. Lima-de-Faria, of the Institute of Genetics of the University of Lund, and finally on "Lamellibranch Muscle" by J. Bowden, of the Anatomy Department of the Queen's University, Belfast. These valuable studies are all of the highest standard, and it is regrettable that they cannot be reviewed here at length.

Looking back on the various volumes of this series, which have appeared under the guidance of Bourne and Danielli, one is impressed with the fact that the problems encountered in the study of the living cell nowadays seem to become more complex and more insoluble. It would be pretentious for us to think otherwise. J. BRONTE GATENBY

A Defence of Free Learning

By Lord Beveridge Pp xiv+146 (London Oxford University Press, 1959) 18*s* net.

IN this book Lord Beveridge has drawn in the main on the documents collected for their work by the Academic Assistance Council and the Society for the Protection of Science and Learning to give a sober but moving narrative of twenty-five years work in Britain to help university teachers and scholars driven from their work on political or racial grounds It is not a philosophical or theoretical argument for academic freedom but a factual account of what has been done in Britain alone, beginning with the expulsions from Germany initiated by Hitler in 1933 and continuing down to the problems presented by the intolerance persisting after the Second World War, including the Hungarian persecution of 1956-57 It is a story little known outside the universities and is told without embellishment, save, perhaps, where in his concluding chapter "The Folly of Tyrants", Lord Beveridge, summarizing, points to the rich harvest which Britain has reaped by her reception of these refugees There are indeed some dark places in the story and Lord Beveridge does not attempt to conceal them On the other hand, he does not overstress them and points out fairly enough that, even in the darkest hour of 1940, there were always those in Britain ready to protest vigorously against administrative error or tardiness and to insist on the revocation of stupid decisions Five debates in the House of Commons in less than eight months of desperate war testify to a sense of justice and a vigilance of which Britain has a right to be proud The most moving chapter is, perhaps, that entitled "Wandering Scholars", in which Lord Beveridge sets forth some of the typical experiences of these scholars collected from their replies to an inquiry sent out in June 1958 No eloquence could make the human issues plainer, nor is more needed by way of argument to demonstrate that here is a continuing problem calling for forethought and imagination, as well as practical help if its difficulties are to be resolved and some of the existing gaps, notably in relation to professional work, are to be closed

In writing this book, Lord Beveridge has added to the debt which Britain as well as wandering scholars owe him and his colleagues, first on the Academic Assistance Council and then in the Society for the Protection of Science and Learning

R BRIGHTMAN

Systematic Mineralogy of Uranium and Thorium

(Bulletin 1064, U S Geological Survey) By Clifford Frondel Pp viii+400 (Washington · U S Govt Printing Office, 1958) 1 50 dollars

FOR the past ten years an intensive investigation into the mineralogy of uranium and thorium, undertaken in connexion with economic studies of radioactive ore supplies, has been in progress in the laboratories of the U S Geological Survey, the U S National Museum, and the Mineralogical Department of Harvard University The vast amount of new information forthcoming from these researches has now been assembled by Prof Frondel of Harvard, in a monograph which is quite the most outstanding work among the half-dozen or more major text-books on radioactive mineralogy that have appeared in the U S S R , North America and France during the past two years Each of close on a hundred mineral species is very fully described according to its synonymy, composition, crystallography and crystal habit, physical and optical properties (with X-ray powder diffraction interplanar spacings), synthesis, criteria for identification, mode of formation, and natural occurrence Comprehensive determinative tables are given in an appendix and there is a bibliography of 800 items Although the work has been three years in the press and thus gives no account of the most recent discoveries, no earlier book in this field has achieved anything like the same coverage and certainly none can parallel this inexpensive Bulletin in accuracy of data and freedom from misprints Most of the opaque multiple-oxide minerals of uranium, other than species of economic importance such as brannerite, davidite, and the pyrochlore-microlite series, have still to be studied in detail , for the rest, the many geologists and mineralogists now concerned with uranium ores will unhesitatingly accept this monograph as their foremost authority.

C F DAVIDSON

Numerical Analysis and Partial Differential Equations

By George E Forsythe and Paul C Rosenbloom (Surveys in Applied Mathematics, Vol 5) Pp x+204 (New York John Wiley and Sons, Inc , London Chapman and Hall, Ltd , 1958) 60*s* net

THIS survey contains two unrelated essays In the shorter of the two, Forsythe summarizes recent work in numerical analysis, with special references to developments in the U S S R There is an account of the chief Russian automatic computers, details of which have been available only in the past two or three years Forsythe also stresses the skill with which Russian workers have brought to the service of numerical analysis some of the most up-to-date tools of pure mathematics, such as constructive function theory and functional analysis The bibliography is helpfully selective rather than blindly comprehensive, and the author's comments on the various items are crisp and efficient

Rosenbloom's essay does not attempt to describe all recent contributions to the study of partial differential equations, but it gives a valuable indication of the way in which the theory of function spaces and the transform calculus have yielded fresh results about elliptic and parabotic equations. The young research worker should find this a helpful guide to some of the main lines of advance ; the bibliography, of some 700 items, may well frighten the novice, and some further annotation would have been an advantage.

T A A BROADBENT

Clinical Biochemical Method.

By Dr A L Tárnoky Pp x+239 (London Hilger and Watts, Ltd , 1958) 50*s* net

MOST large clinical biochemistry laboratories have their own particular methods for routine examinations, or more likely use modified classical ones in the light of their experience Dr A L Tárnoky's book describes the methods used routinely in his laboratory at the Royal Berkshire Hospital It is a straightforward bench manual giving most of the usual tests arranged in alphabetical order Each test is described under the headings of principle, specimen required, method, result, normal value, reagents required and remarks There is a small but valuable appendix which gives procedures for checking analyses in a laboratory, lists of books and references and a list of manufacturers There are only a few diagrams , for the class of worker who would most depend on this book, spectroscopic charts and illustrations of electrophoretic patterns, for example, would have been of great value Again, the omission of any mention of paper chromatography or of serum transaminase tests is noticeable On the other hand, the directness and simplicity of the text are much to be commended

This book will be very useful to technicians, clinical pathologists and doctors in smaller hospitals in Britain and overseas, and to medical research workers who need to do routine clinical biochemical tests as part of a larger research scheme It forms a useful addition to the larger and more well-known text-books of clinical biochemistry

D S H W Nicol

Biological Laboratory Data

By Dr L J Hale (Methuen's Monographs on Biological Subjects) Pp x+132 (London Methuen and Co , Ltd , New York John Wiley and Sons, Inc , 1958) 15*s* net

BOOKS intended as laboratory aids are by no means rarities and cover a great variety of subjects, while they range in their appeal from the beginner to the advanced research worker This book falls rather into the latter category and it has some unusual features which single it out among those devoted to the biological sciences The emphasis on the mathematical side, for example, is conspicuous Out of a total of one hundred and twenty-seven pages, twenty-three deal with mathematical data, twelve are devoted to statistical data and formulæ and thirty-five to physical and chemical data This is not an overweening proportion but it is more extensive than in most books of this size and type and the material is very handily presented

The result, however, has been somewhat to repress the more strictly biological matter, so that cultural methods for the laboratory get only seven pages, inclusive of a page of references to other works, while histological and histo-chemical data cover only fourteen pages This seems meagre considering the enormous amount of such data available and a better balance might easily be achieved There is no doubt, however, of the value of the material which the book contains and the mathematical sections alone should ensure it a wide popularity among biologists, who so often feel the need of guidance in that field

R C McLean

The Salmon

By Dr J W Jones (New Naturalist Special Volume) Pp xvi+192+12 plates (London William Collins, Sons and Co , Ltd , 1959) 18*s* net

ON the whole Dr Jones has written a readable book The chapters dealing with the spawning of adult salmon and young males are the best in the book, as it is there that Dr Jones has drawn largely from his own work and experiences An important chapter is devoted to scale reading from which many of the details of the life-history of the salmon have been discovered

The chapter on "Salmon in the Sea" is frankly disappointing, as sufficient use has not been made of the information amassed in the past thirty years, so the reader does not get a clear picture of the long migrations which salmon often make when returning to the river of their birth

Other chapters deal with the early life of the salmon, the return to the river, the return to the sea and the salmon river The book is completed by four useful appendixes dealing with the characters of salmon and trout and their hybrids, a key to the genera of the Salmonidae, etc , a description of the parasites of salmon and methods of estimating lengths from scales Serious readers will also find the bibliography of value in their more extensive reading

One serious criticism of the book I have to make is that many of the illustrations are poor The publishers inform us in a note opposite the title page that in this series of publications "the animals and plants are described in relation to their homes and habitats with the *help of fine photographs*", the italics are mine Plates 4, 5, 6 and 7 are certainly not based on fine photographs as I have often seen better in angling magazines

Arthur E J Went

Nitration of Hydrocarbons and other Organic Compounds

By A V Topchiev Translated from the Russian by Catherine Matthews Pp vi+329 (London and New York Pergamon Press, 1959) 90*s* net

TRANSLATIONS of foreign texts are seldom successful unless carried out by workers in the same field with freedom to incorporate recent material The pitfalls are well illustrated by this book, which is both out of date and unreadable There are one or two references to papers published early in 1954, but none to the more recent literature Since much work of fundamental importance to this field has been published during the past five years the book is of little value as an account of the subject, although it does contain a rather complete account of the earlier literature and a useful summary of Russian papers that are not readily accessible in Britain

It is most unfortunate that the distinguished author of the book could not have been persuaded to revise it during translation

M J S Dewar

Commonwealth Universities Yearbook, 1959

Pp xxvii+1407 (London Association of Universities of the British Commonwealth, 1959) 84*s* , 13 dollars

THE invaluable "Commonwealth Universities Yearbook" is now in its thirty-sixth edition There are no major changes from last year's edition, when the new enlarged format was introduced, but the size has increased from 1365 to 1435 pages, mainly in order to accommodate expansions in university staff

The University of Sherbrooke in Canada and Sardar Vallabhbhai Vidyapeeth in India are mentioned for the first time, and the University College of Fort Hare in South Africa now has a complete entry Two events which occurred in Australia as the book was going to press are also mentioned briefly the founding of Monash University in Victoria and the transformation of the New South Wales University of Technology into a multi-faculty University of New South Wales

The valuable essays in higher education in the various countries have been brought up to date, and where necessary additions have been made to the maps showing where the universities are located

New features of this edition include a full-length summary of admission requirements by the Canadian Universities, and information on the transfer courses at certain British universities whereby students who have previously studied arts subjects can switch to science

BEHAVIOUR IN CONVENTIONAL AND EXTRA-TERRESTRIAL FLIGHT

SOME FUTURE ASPECTS OF AVIATION MEDICINE

By AIR COMMODORE W. K. STEWART, C.B.E., A.F.C.

Royal Air Force Consultant in Aviation Physiology, Institute of Aviation Medicine,
Royal Air Force, Farnborough

AVIATION medicine is the normal clinical practice of medicine as applied to the special circumstances of flight; but in this survey it refers to the basic sciences of physiology, psychology and biochemistry.

The growth of aviation medicine has been largely due to preceding advances in combustion, aerodynamics and metallurgy; in turn, these advances were the result of operational plans, either civil or military. At the present time, most aircraft or missiles appear to have a cycle of approximately ten years for the stages of planning, development and production, and it is reasonable to assume that some such cycle will be entailed in the future. Past experience in the conduct of biological research has indicated that such a period should be sufficient for the production of the major contributions from aviation medicine. It is also sufficient for the design and installation of the capital equipment required, both for fundamental and applied work.

It has become clear, however, that a significant contribution to a particular phase of the programme will depend on adequately trained staff. No institute or laboratory of aviation medicine will survive in the future if it lacks staff of the proper orientation in the relevant biological disciplines.

Since these are likely to be of a complex kind, skilled research workers will be correspondingly few in number. It is held, therefore, that it is necessary to plan future activities in aviation medicine so as to ensure the early derivation of biological information.

Survey of Some Future Problems

For the purpose of this review, it will be assumed that manned aircraft will continue to be used in an era of unmanned ballistic missiles, or vehicles, and later in an era of orbital-manned vehicles. Such aircraft may be hypersonic, may operate at low altitudes, or in the outermost layers of the atmosphere, for short or very long durations. They will subject their occupants to stresses and environmental changes, different in degree, but on the whole basically similar to those of contemporary aircraft, and this, to some extent, may be also true for orbital-manned vehicles.

The experience gained in the past fifteen years in applied physiology and psychology is sufficiently extensive to encourage the belief that problems arising in these disciplines can be successfully solved, since the techniques involved and equipment necessary can be foreseen to a considerable extent.

For extra-terrestrial flight, many of the problems, weightlessness, for example, can only be solved either by extrapolation from poorly quantified data, or by direct experience.

Hazards such as the effects of corpuscular radiations and cosmic rays will almost certainly be a more worthwhile sphere for laboratories of physics than for an institute of aviation medicine. In considering the philosophy of extra-terrestrial flight, it is always difficult to justify biological participation since apart from the remote possibility of acquiring data of importance to microbiology, it is unlikely that purely physiological studies will advance general knowledge in proportion to the cost of the venture.

The proper function of biological researches is undoubtedly to further manned exploration of the upper atmosphere or beyond, and even here it is wise to hesitate in considering, not whether this is feasible, but whether it can ever lead to more than an *ad hoc* determination of the ultimate limits of man's endurance.

However, the value of manning a satellite may ultimately depend on those functions of the central nervous system which are difficult to simulate, either in absolute terms or in size and weight. It is probable that what a man can be expected to do in a satellite could only be determined by actual experience; but it is unfortunate that the environmental conditions which he will encounter are those most likely to affect the logical and purposive functioning of the brain.

The problem here is that the behaviour of animals and man is still very far from being understood; aberrations of behaviour in flight are still more difficult to investigate, and if any occur in the occupant of a satellite the determination of their basis might be quite impossible. Clearly, advancement of such knowledge would be of benefit, not only to those nations with official programmes of the 'man in space', but also to aviation in general, and would constitute a field in which expenditure of effort and money would be justified.

Every practitioner of aviation medicine has some acquaintance with cases of abnormal behaviour in flight. For many of these cases, no simple answer can be given, although they are commonly referred to as 'manifestations of disorientation', but analysis of near accidents has shown a higher frequency than suspected of misinterpretation of visual information and illusions of different kinds.

Some of these illusions were hypnagogic in nature; others led to panic or startle reactions. Some were obviously associated with reduction in sensory input and probably an element of perceptual conflict. In future manned flight, there will be an increased exposure to the factors probably initiating such changes in behaviour It has therefore become mandatory to review their relationship to physiological mechanisms, and to try to determine the primary stimuli for chains of reaction Do disorders in behaviour determine physiological events, or is it necessary to postulate underlying abnormalities in the neuro-physiological or homœostatic spheres ? Probably both mechanisms are implicated at different times

The classical problems of behaviour in flight, such as fear and fatigue, are entirely material to this argument Hence it is essential to derive such advances in knowledge that adequate theories can be constructed, adequate in the sense that they can produce methods of prediction of alterations in learned behaviour under stress, whether this stress be neurogenic or systemic in origin The purpose of this review is to indicate some avenues of research which could be explored and which might prove of value, not only in conventional aviation medicine, but also in what is rather loosely termed 'space medicine'

Survey of Brain Mechanisms

It is impossible to prophesy how far theories of integration of nervous action will have advanced in the era of the hypersonic aircraft and manned missiles, and it is therefore probably legitimate to commence with Hebb's[1] ideas concerning the conceptual nervous system He related the function of the brain-stem, or arousal system of Moruzzi and Magoun[2], to the level of the 'cue' function in learning For general reviews of the physiological and psychological aspects those of Jasper, Gloor and Milner[3] or Duffy[4] should be consulted

Stress It is proposed to regard stress from the point of view of Fortier[5] and Fortier *et al* [6], namely, that there are basically two types of stress—neurogenic, initiated through perceptual processes, and systemic, initiated through chemical and metabolic processes In both, the hypothalamus appears to influence anterior pituitary secretion via the hypophyseal portal vessels Permanent interruption of these vessels lowers the normal rate of secretion of adrenocorticotrophic hormone, abolishes reflex secretion of adrenaline in response to stress and also that of the gonadotrophic and thyrotrophic hormones There are indications that the tasks of flight can be regarded in these terms as a stressful occupation, with enhancement of the secretion of adrenaline and noradrenaline, of the output of 11- and 17-ketosteroids, or uro-pepsinogen accompanied by alteration in gastric function

It has not, however, been possible to state that the degree of stress represented by biochemical findings is of unusual severity or to relate them to the degree of fatigue experienced The fact that aircrew trainees hyperventilate more or excrete more ketosteroids than their instructors may merely represent higher levels of arousal than higher intrinsic levels of stress If stress and arousal be synonymous, then it may be necessary to postulate that certain forms of learning set represent stress also Unfortunately it is impossible to investigate the immediate physiological reactions of man exposed to an overwhelming event such as a major loss of control in the air

Further, the physiological parameters which had been investigated in the intact man are second- or even third-order variables , but this does not deny the importance of techniques, such as those of Malmo and his associates[7] It would seem to be important to extend their approach possibly by applying techniques, such as Merton's[8], in order to derive more fundamental knowledge of how anxiety may alter reflexive physiology

If a given level of arousal be equated with stress, then a reduced sensory environment should also, from some points of view, be regarded as stressful In future aircraft or vehicles, in which such factors may well operate, and may be enhanced by fatigue, there will also be the interposition of alterations in environmental and temporal rhythms Both these states may be found in nuclear-powered aircraft as well as satellite or orbital vehicles, and some understanding of their inter-relationship is certainly necessary The approach of Lewis and Lobban[9] into biochemical aspects of alterations in environmental time should be combined with that of Bexton, Heron and Scott[10] into the intellectual effects of perceptual isolation

Behaviour during stress In the future it will be important to ensure that memory and learning will remain as stable as possible during acute stress occurring in a crucial period of a sortie

Tyhurst's[11] study of behaviour in disaster situations on the ground is especially significant in that 75 per cent of individuals affected showed definite impairment of decision-taking, and it is likely that in any normal population of aircrew there must be a significant proportion of men who would evince similar reactions Even if the motivation and training are different, it would be desirable for their safety to select crews in which the 'cue' function alters as little as possible with high levels of arousal In order to do this, much more knowledge will have to be acquired by neurophysiologists

Vogt[12] has pointed out that not only are the hypothalamus and the reticular activation systems of the brain-stem particularly rich in sympathin content but also that loss of this content is accompanied by an increase in secretion from the adrenal medulla It may also be significant that the non-specific thalamic nuclei contain more than three times as much sympathin as the specific thalamic nuclei, since Mahut[13] has demonstrated that electrical stimulation of the non-specific intralaminar nuclei can produce learning deficits in rats provided that stimulation occurs within a given period of the activation of the cell-assemblies concerned

Activity in the arousal system does not stop abruptly following a sensory stimulus, probably because of release of adrenaline Rothballer[14] has determined that the system is likely to be composed of adrenaline-sensitive elements which give an immediate arousal effect upon the electroencephalograph, and other adrenergic or transmitter elements, which are responsible for the long-lasting effects In any stressful situation such as flight, the level of arousal is probably at an optimum as a result of prolonged training , it is also envisaged that the level of circulating adrenocorticotrophic hormone and the feed-back control of the blood value of adrenocortical hormone are also stabilized at a high normal value What happens to this system when a new situation arises in flight which may have originated from lapses in attention or perceptual conflict ?

It can be postulated that corticofugal impulses along the descending pathways to the arousal system[15] may reduce its noradrenaline content and initiate the reflex discharge of adrenaline from the adrenal medulla , and the new level of circulating adrenaline may affect adversely the stability of the arousal system.

It is important to consider that the neurogenic stimulus must be maximal, and the rate of build-up of disorganization of perception must be sudden. Too often one elicits histories of near-accidents of this type: "I have been teaching jet instrument flying for some time with complete confidence in the right things happening if the right control movements are made; but on this occasion, panic and delusion completely took control of my faculties, and I was unable to think and act as I knew I should." Here is a sudden misapprehension leading to a sudden effector activity and the rapid rate of loss of control in high-performance aircraft only reinforces the "panic and delusion".

Despite the fact that the injection of adrenaline into the lateral ventricles of cats produces behavioural effects similar to light barbiturate anæsthesia[16], and despite the probable existence of neurohumoral loops as postulated by McDermott *et al.*[17], how does the disorganization of integrated behaviour arise?

Milner[18] has further elaborated Hebb's theory in the light of recent advances in neurophysiology, and in particular with introduction of the concept of neural inhibition as an active process. This has been demonstrated in the spinal cord on mono-synaptic reflexes by Eccles and his co-workers[19], both by physiological and pharmacological techniques (Curtis *et al.*[20]) and in the neurones of the motor cortex by Li[21].

Even if it is difficult to extrapolate from observations on single neurones by micro-electrode techniques to the organized behaviour of the whole animal and thence to man, the fact that active inhibition can be demonstrated in neurones is of extreme importance. But does one require to postulate the presence in the central nervous system of substances which appear to have an inhibitory action upon dendritic function[22]?

The maintenance of efficient performance in future tasks will depend to a considerable extent on whether there is impairment of attention or vigilance by either fatigue or stress. Mackworth[23] has demonstrated the importance of vigilance in work tasks, and it may be postulated that in any form of ballistic vehicle there may well be increased lag in perceptual feed-back with an enhanced rate of impairment in vigilance.

This is related to two neurophysiological problems in the mechanism of attention. Where and how does the inhibition of a sensory input occur when a more effective perceptual stimulus is presented? And what is the relationship to habituation?

Sharpless and Jasper[24] have already shown that habituation occurs readily in the arousal system when a tone is presented repetitively, but that re-arousal occurs when the frequency of the tone is altered. This is a situation well known to aircrew, who may first gain cognizance of an impending emergency from aberrant noise in the engine.

In the conscious animal, neurophysiological techniques such as indwelling micro-electrodes are of the greatest importance to the elucidation of these problems, particularly when the experimental orientation includes psychological constructs. There are also indications that neuropharmacology may well be implicated.

Hebb[25] has summarized the data on the function of acetylcholine in the central nervous system by stating the situations or cell-masses to which it appears to be limited. There may be significant contributions to theory if there were any relationship between the rich content of acetylcholine in the caudate nucleus and the selective impairment of the delayed alternation response in the monkey produced by stimulation[26]. Acetylcholine, as well as adrenaline, has a direct action upon the neurones of the reticular system[27], and both drugs have no direct effect upon specific sensory projection systems. The use of micro-injection techniques might elicit much data which may elucidate the physiology of the central of sensory inflow. Dawson[28] has reviewed the evidence for the existence of mechanisms of this nature which suggests that there might be a continual control on afferent sensory transmission from centres in the cortex, brain-stem or cerebellum.

Since attention is a much more subtle process than can be accounted for by the arousal system, a controlled sensory block is of great interest and may be the basis for the direction of perception or the selective use of cues. However, arousal does tend to depress evoked cortical potentials in an 'unattended' sensory modality and an element of behavioural alarm may be essential for some of the inhibitory changes which accompany shifting of attention[29].

Neurophysiological studies of such changes should further the establishment of psychological theories of attention.

Inter-Disciplinary Research

If it were possible to measure in any individual, values for learning or 'cue' functions, in relation to values of arousal as affected by environmental or emotional processes, then some estimate of the probable stability of an individual's behaviour during exposure to neurogenic stress might be obtained.

A general approach could be adopted initially in which pilots who have experienced certain types of near accident could be compared with pilots who have not had illusions in flight. Some techniques are more appropriate than others; Stennett[30] has shown that an inverted *U* relationship exists between performance-level and level of arousal, using as criteria palmar conductance, electromyographic gradients and the alpha component of the electroencephalograph. It is probable that such techniques would merely give group identification, and the relative placing of any one individual within a group would not be sufficiently accurate for practical purposes.

For more detailed investigation, use could be made of flight simulators of modern type situated in a reduced sensory environment. The aim would be to repeat in some degree the observations of the Cambridge Cockpit Group, and when fatigue had resulted in lapses of attention, or decrease in vigilance[31], to introduce a perceptual conflict in orientation. Not only would such methodology require development, but also physiological variables should be recorded which show less temporal independence than the electroencephalograph and palmar conductance.

In order to investigate the effects of neurogenic stress upon man, methods of inducing fear or anxiety are obviously required, other than the usual ones of incentives or pain[32]. Again, use can be made of isolation, by immersion in water[33]. If it were possible, for example, to create an illusion of sudden reversion of bodily orientation, data of great interest could be derived from the recording of such variables as electroencephalograph, pulse-rate, respiration electromyograph and muscle blood flow by electronic means.

The correlation of results with anterior pituitary and adrenal activity would be clearly desirable; but it would be essential to employ techniques which would give more direct functional measures than eosinophil counts or urine extractions. Bush and Sandberg[34] have established by chromatography the identity of the major circulating adrenocortical hormone in human plasma as 17-hydroxycorticosterone (compound *E*), although the amounts are small. Nelson *et al.*[35] found only 4–10γ per 100 ml. of whole blood in resting normal subjects.

Even if the aggregate of data from such investigations would prove to be of considerable value, it is unlikely that their interpretation could adequately decide orders of precedence in events, so that considerable animal experimentation is clearly required.

Investigations on Animals

Rats. It has been postulated that the general stressful conditions of flight lead to a sustained increase in activity of the hypothalamic-pituitary-adrenal axis; it is known that an intravenous injection of adrenocorticotrophic hormone leads to an increase in output of hydroxycorticosterone within 10–20 min., and that continuous infusion of the same amount of adrenocorticotrophic hormone leads to a sustained rise in adrenal output.

Though enough is known about the peripheral or somatic actions of corticosteroids, very little is known about their action on the central nervous system and nothing about the stability of the feed-back control of the enhanced level of cortico-steroids on man. It is evident from animal data that there is a neurohumoral loop of some magnitude which should have some central as well as peripheral actions, but which has a delay of minutes and is therefore probably concerned with metabolic rather than primary nervous activity. For example, this loop might be concerned with the maintenance of arousal but scarcely with rapid alterations in the level of arousal.

Vogt has speculated that the rich content of sympathin, in the reticular system and hypothalamus, may have a behavioural function; reduction in content is caused by the administration to dogs of drugs known to effect stimulation of the sympathetic nervous system and the reflex release of adrenaline. Purpura[36] has demonstrated, in cats with crossed circulations, the persistence of arousal or electrical excitability of the cortex, after cessation of stimulation of the bulbar reticular formation in the ipsilateral animal. He also demonstrated similar effects in the unstimulated animal, but with a delay of 30–80 sec.

It is possible, therefore, that stress, by causing increased activity in the brain stem reticular formation and a reflex secretion of adrenal medullary hormones, influences cortical activity in a non-specific manner. Intense stimulation of this second hormonal loop within a generally stressful environment, which has already resulted in enhanced activity in the production of corticosteroids, may have some relationship to abnormalities in behaviour.

There are many factors which are still unknown. The role of the limbic system of the brain has received much attention in various aspects of responses to stress, particularly with reference to emotional behaviour; but little is known of its possible relationship to the hypothalamic control of hormonal output, except that the reticular system is probably implicated. Again, the relationship of the sympathica-adrenal medullary system to the pituitary adrenal cortical system has many puzzling factors. In man, Sandberg *et al.*[37] found no effect from the infusion of adrenaline on adreno-cortical secretion but Harwood and Mason[38] found a fairly marked effect on the dog.

It is therefore proposed that studies be carried out on the possible relationship of various aspects of behaviour and the activity of the brain-stem reticular formation as determined indirectly by its sympathin content or by the output of cortico-adrenal steroids.

Beach[39] found that morphine injections result in a significant increase in exploratory behaviour in rats, as compared to a control group, but not as compared to a hungry group. He considered that this effect was probably due to lowering of perceptual threshold through increased activity of the reticular formation of the brain stem, but he did not relate his findings to those of Vogt[40], who found that morphine caused loss of hypothalamic sympathin with concomitant secretion from the adrenal medulla.

Again, Petrinovitch and Bolles[41] found in studies on delayed alternation in rats that 12 out of 16 animals met the criterion of learning—the remainder could never learn to alternate their responses on the *T*-maze. These animals were subjected to a water deprivation schedule and it was found that in order to develop the delayed alternation response to its full, a loss in body-weight of 20 per cent was necessary. Although it was concluded that memory served as a cue for the correct response, no further investigation was made into the failure in training of the four rats which did not lose weight.

Thirst schedules are used in many comparative psychological investigations in order to induce a learning set, but the probable physiological processes involved are infrequently considered. Hunger is usually considered as a drive. However, Hebb[42] has equated drive with arousal on the hypothesis that an increase in drive or arousal from a low to a moderate level and likewise a decrease from a high to a moderate level will favour the learning of responses.

All initial handling of rats should therefore be considered as stressful, and the physiological literature abounds in warnings that even methods of examinations involving taking of blood induce an eosinopænia. The literature of this aspect of psychology is also large; not only does constant handling affect growth and resistance to stress, but it also affects behavioural performance, such as reduction of numbers of errors in re-learning on a water-filled closed-field maze.

It would appear to be worth while investigating the influence of some of those methods used in physiological psychology on, for example, the corticosterone content of rats' adrenals, the animals being killed by rapid decapitation, analysis being carried out by paper chromatography[43]. Holzbauer[44] has demonstrated that, in decapitated rats, the hormonal stores of the adrenal cortex reflect the secretion-rate at the time of death. She found significant variations between unstressed rats belonging to different colonies; but the largest differences were between stressed and unstressed rats.

For example, the influence on intelligence of rearing rats in a free environment, as determined by the closed-field test of Rabinovitch and Rosvold[45], should be re-investigated , if there should be any correlation between corticosterone secretion and behaviour under these conditions, then it might be possible to show some relationship between the response of the adrenal cortex and 'brightness' and 'dullness' within similar strains

Dogs The biochemical properties of the adrenal cortex of each species are probably specific and genetically determined The secretion of the rat is unlike that of most other experimental animals and also of man, but those of the dog and the monkey are sufficiently similar to man, since a large proportion of the total secretion would appear to be compound *E*

Consideration should therefore be given to the dog as an experimental animal, if results of significance can be derived from experiments with rats

The general plan of these further behavioural studies might well follow that of Thompson and Heron[46], who investigated the effects of early experience on both the problem-solving capacity of dogs and on exploratory activity They found that the dogs reared in an environment which was restricted in perceptual content evinced significantly greater activity, but had a permanent decrement in intelligence compared to their litter mates which were reared in a normal environment

24-hr food deprivation schedules were used in trials on delayed reactions and it can be postulated that the stress of testing was different in the two groups

In four normal dogs, delays of 240 sec were achieved after an average of 230 trials, but the restricted dogs could not achieve any delay If a modification of Vogt's technique[40] for the estimation of sympathin in the central nervous system were used, then it might be possible to relate the sympathin content of the reticular formation and the intralaminar thalamic nuclei to differences in behaviour

If the sympathin content were higher in the normal dogs, then it could be deduced that the impaired learning of the restricted dogs was related to the activity of the reticular formation , but further experimentation would be required to relate the strength of drive or of drive reduction to learning

A series of investigations on learning set might provide more data of significance It is known that stimulation of the central median nucleus of the thalamus (non-specific) produces facilitation of cortical sensory neurones[47] , also stimulation of intralaminar nuclei may interfere with learning If these findings be related, then during the formation of learning set, two physiological processes may be involved—the determination of the motor response by the linkage of the appropriate active cell assemblies and the progressive reduction in the activity of the arousal system

Determination of this latter by Vogt's techniques might be more meaningful to behaviour studies than micro-electrode techniques

Summary

The future problems in aviation medicine are subtle and difficult Many are concerned with the determination of behavioural responses to neurogenic stress in conditions where it is impossible to reproduce fully this stress on the ground It would appear that studies on man should be supplemented by animal investigations and that a multi-disciplinary approach would enable adequate theories to be constructed on the relationship of alterations in perceptual learning to stress

With the verification of such theories or important parts of them, it should be possible to derive new selection processes for personnel involved in future flight or extra-terrestrial travel

Acknowledgment is made to Prof D O Hebb and his staff for their patience and kindness while I was on leave of absence from the Royal Air Force and studying in the Psychology Department of McGill University, Montreal

[1] Hebb, D O , *Psych Rev* , **62**, 243 (1955)

[2] Moruzzi, G , and Magoun, H W , *EEG Clin Neurophysiol* , **1**, 455 (1949)

[3] Jasper, H , Gloor, P , and Milner, B , "Ann Rev Physiol ", **18**, 359 (1956)

[4] Duffy, E , *Psych Rev* , **64**, 265 (1957)

[5] Fortier, C , *Endocrin* , **49**, 782 (1951)

[6] Fortier, C , Harris, G W , and McDonald, I R , *J Physiol* , **136**, 344 (1957)

[7] Malmo, R B , *Psych Rev* , **64**, 276 (1957)

[8] Merton, P A , *J Physiol* , **114**, 183 (1951)

[9] Lewis, P R , and Lobban, M C , *J Physiol* , **133**, 670 (1956)

[10] Bexton, W H , Heron, W , and Scott, T H , *Can J Psychol* , **8**, 70 (1954)

[11] Tyhurst, J S , *Amer J Psychiat* , **107**, 764 (1951)

[12] Vogt, M , *Brit Med Bull* , **13**, 166 (1957)

[13] Mahut, H (personal communication, 1957)

[14] Rothballer, A B , *EEG Clin Neurophysiol* , **8**, 603 (1956) , **9**, 409 (1957)

[15] Brodal, A , "The Reticular Formation of the Brain Stem" (Oliver and Boyd, London, 1957)

[16] Feldberg, W , *Proc Roy Soc Med* , **48**, 853 (1955)

[17] McDermott, W V , Fry, E G , Brobeck, J R , and Long, C W H , *Yale J Biol Med* , **23**, 52 (1950)

[18] Milner, P M , *Psych Rev* , **64**, 242 (1957)

[19] Eccles, J C , "The Neurophysiological Basis of Mind" Waynflete Lectures (Clarendon Press, Oxford, 1953)

[20] Curtis, D R , Eccles, J C , and Eccles, R M , *J Physiol* , **136**, 420 (1957)

[21] Li, C H , *J Physiol* , **133**, 40 (1956)

[22] Iwama, K , and Jasper, H H , *J Physiol* , **138**, 365 (1957)

[23] Mackworth, N H , Med Res Counc Spec Rept Ser No 268, 156 (1950)

[24] Sharpless, S K , and Jasper, H , *Brain*, **79**, 655 (1956)

[25] Hebb, C O , *Physiol Rev* , **37**, 196 (1957)

[26] Rosvold, H E , and Delgado, J M R , *J Comp and Physiol Psych* , **49**, 365 (1957)

[27] Bradley, P B , and Mollica, A , *J Physiol* , **140**, 11 (1958)

[28] Dawson, G D , *Proc Roy Soc Med* , **51**, 531 (1958)

[29] Horn, G (unpublished work)

[30] Stennett, R G , *J Exp Psychol* , **54**, 54 (1957) , *EEG Clin Neurophysiol* , **9**, 131 (1957)

[31] Bartlett, F C , *Proc Roy Soc* , B, **131**, 247 (1943)

[32] Stewart, W K , Ruffell Smith, H P , Williams, D , and Tompkins, V H , *Proc Roy Soc Med* , **48**, 868 (1955)

[33] Lilly, J C , Amer Psychiat Assoc Psychiat Res Repts , **5**, 1 (1956)

[34] Bush, I E , and Sandberg, A A , *J Biol Chem* , **205**, 783 (1953)

[35] Nelson, D H , Samuels, L T , Willardson, D G , and Tyler, F H , *J Clin Endocrinol* , **11**, 1021 (1951)

[36] Purpura, D P , *Amer J Physiol* , **186**, 250 (1956)

[37] Sandberg, A A , Nelson, D H , Palmer, J G , Samuels, L T , and Tyler, F H , *J Clin Endocrinol Metab* , **13**, 629 (1953)

[38] Harwood, C T , and Mason, J W , *Amer J Physiol* , **186**, 444 (1956)

[39] Beach, H D , *Can J Psychol* , **11**, 237 (1957)

[40] Vogt, M , *J Physiol* , **123**, 451 (1954)

[41] Petrinovitch, L , and Bolles, R , *J Comp Physiol Psychol* , **50**, 363 (1957)

[42] Hebb, D O , "A Textbook of Psychology" (W B Saunders Co , Philadelphia, 1958)

[43] Vogt, M , *J Physiol* , **130**, 601 (1955)

[44] Holzbauer, M , *J Physiol* , **139**, 294 (1957)

[45] Rabinovitch, M S , and Rosvold, H P , *Can J Psychol* , **5**, 122 (1951)

[46] Thompson, W R , and Heron, W , *Canad J. Psychol* , **8**, 17 (1954)

[47] Li, C H , *J Physiol* , **131**, 115 (1956)

A BONE IMPLEMENT FROM STERKFONTEIN

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A MEASURE of controversy has been aroused by Dart's thesis that *Australopithecus* used bones, horns and teeth as implements. Evidence for this view has mainly come from Makapansgat, but it is the purpose of this article to report the discovery of a bone implement at Sterkfontein. This single find supports Dart's view in proving that bone was employed artificially in the Transvaal during the known australopithecine period ; on the other hand, whether this new find represents australopithecine handiwork is quite a different matter.

The specimen under consideration was found on June 4, 1958, during a five-month excavation season devoted to further exploration of the Sterkfontein extension site. This abuts on, and is continuous with, the type site from which approximately a hundred specimens of *Australopithecus* have been recovered. As already reported[1,2], the Sterkfontein deposit (type plus extension sites) consists of three different breccias : (*a*) lower or type site breccia, which has yielded numerous *Australopithecus* remains but neither stone artefacts nor *Equus* ; (*b*) middle or red-brown breccia, which has yielded 228 stone artefacts, a few small pieces of *Australopithecus* as well as remains of *Equus* ; (*c*) upper or brown breccia, which is thin and patchy and has yielded *Equus* but neither *Australopithecus* nor artefacts. Where the upper breccia occurs in the area actually excavated, it is separated from the middle breccia by a thin drip-stone or stalagmite. The bone implement was wholly encased in solid red-brown (middle) breccia a short distance below the stalagmite.

The maximum dimensions of the specimen are : length, 9¾ cm. ; width, 3 cm. ; and thickness, 1½ cm. In most places the thickness is roughly a centimetre. It consists of a portion of a long bone which had been split longitudinally. One half was then apparently broken in a manner which left one end pointed. The surfaces resulting from the breaks which formed the point have become polished completely smooth, while most of the natural bone surface has retained its original appearance—except for an appreciable amount of manganous staining. The specimen was originally longer than at present. In excavating the breccia in which it was embedded, it was broken into a number of pieces, all but a very few small pieces being recovered. The butt end was apparently slightly longer before the recent breaking occurred. Evidence of ancient damage to this end suggests that the specimen had originally been even longer.

In view of the differences of opinion which exist about the reality of bone implements associated with australopithecines, it is necessary to examine the reasons for regarding this specimen as an artefact. Two common groups of agencies may produce post-mortem alteration to the natural shape and appearance of a bone. These are (*a*) natural weathering agencies, and (*b*) animals, including man.

Under (*a*) the following may be considered :

(1) *Water*. This could have acted by rolling and abrading the specimen while loose—in a stream-bed, for example. This action would first affect all ridges or other prominences. This is not true of the specimen in question. The most marked smoothing is not on ridges, and at least one fairly delicate ridge is present and scarcely affected. Most of the surface has not been smoothed at all. Rolling may thus be discounted. But water may also have affected the specimen in another way. If the bone became partially exposed by weathering of the breccia, the exposed portion could have been smoothed by sand-bearing water flowing over it periodically while the protected portion remained unaffected. This can also be discounted, since the smoothed portions are related to the unsmoothed portions in such a way that the one could not have been exposed without at least some of the other also. Furthermore, the entire specimen was in solid breccia overlaid by a stalagmite as well as a later breccia. All other bone in the immediate neighbourhood was fresh and showed no signs of artificial smoothing.

(2) *Wind*. Wind-blown sand particles can readily smooth off rock, glass, bone and other such objects.

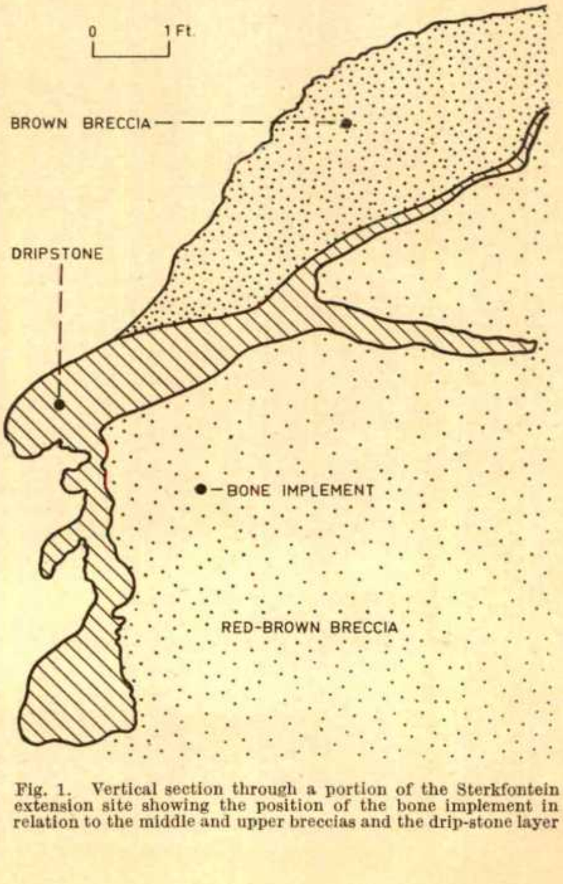

Fig. 1. Vertical section through a portion of the Sterkfontein extension site showing the position of the bone implement in relation to the middle and upper breccias and the drip-stone layer

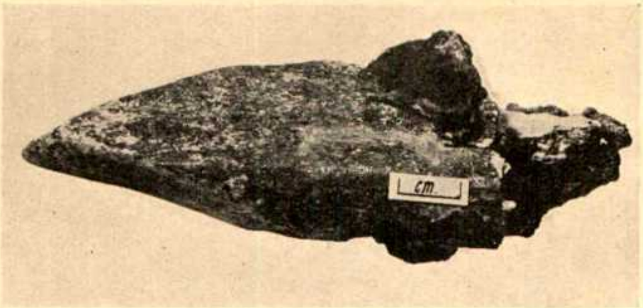

Fig. 2. Bone implement from Sterkfontein. Some breccia is still adhering to the specimen

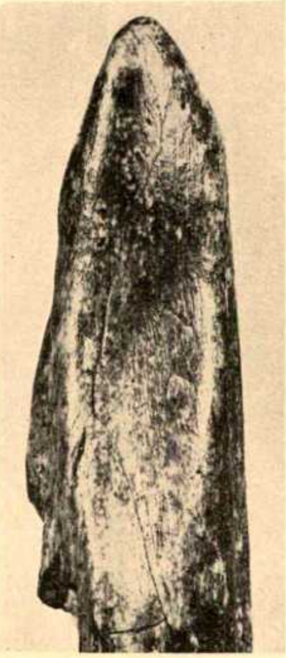

Fig. 3. Enlarged view of apex of the Sterkfontein implement, showing one of the two main polished surfaces

However, this mechanism is indiscriminate in that all exposed parts are affected. The marked localization of the smoothed areas on the specimen and the relationship of smoothed to natural surfaces render wind action improbable in the extreme. Furthermore, the action of blown sand is to produce a fine frosting on the affected surfaces, not a smooth polish.

The nature, relative size and distribution of the artificial surfaces and the circumstances of preservation eliminate also the remote possibility of chemical weathering.

Under (*b*) may be considered :

(1) *Carnivores.* The carnivores which commonly chew bones and which could conceivably be concerned in this instance are hyænas, the larger cats and the dog group. All these splinter the shafts of long bones or consume them entirely. It is impossible to see how any of them could produce either the shaping or the polishing here involved.

(2) *Rodents.* Some modern rodents gnaw bones found lying about, especially in caves. This is particularly true of porcupines, and many fossil bones bear witness to the antiquity of this activity. Unwary observers may be misled by such bones as they are often gnawed along the shafts to produce a sharp edge or around the broken ends of shafts to produce chisel edges and similar effects. Examples occur among the bones found at Hopefield[3]. However, the unmodified results of porcupine gnawing are fairly easy to detect since the marks made by the chisel-shaped incisors are visible. Where weathering has afterwards smoothed the bone, the gnawing may not be easy to detect—as in the case of some of the Hopefield bones which occur in shifting, loose sand where smoothing may thus occur easily.

This cannot be the explanation of the nature of the Sterkfontein specimen. There is no trace whatever of gnawing anywhere on the bone. If the smoothed portions are regarded as areas of weathered porcupine gnawing, then it is difficult to explain why the other parts of the bone are totally unweathered, since a marked degree of weathering would be necessary to remove all traces of gnawing. Examples of rodent gnawing do occur in small numbers in this site and an example is shown in Fig. 5. But neither this nor any of the other bones so far found in this site exhibit the marked differential smoothing found on the bone under discussion.

There appears to be no other reasonable explanation than that a hominid used the bone in a manner which polished smooth the surfaces utilized and did not affect the other parts. This is certainly the immediate impression given by the appearance of the specimen. It does not seem likely that it was used for digging, since soil would affect all surfaces of the specimen at the digging end and would also produce a more scratched surface than is the case. The only possibility seems to be that it was used for scraping or rubbing something with a definite and fairly soft surface—for example, the under-surface of animal skins. Under a stereo microscope a small amount of very fine scratching is detectable on the polished surfaces. This is much finer than that to be seen on Natufian bone implements from Mount Carmel, which show clear evidence of having been shaped deliberately, some of the shaping having been done with a blade of some sort ; some of the other surface marks on these specimens may either have been made with a stone blade with an uneven edge or be the result of use. There is no evidence of cutting on the Sterkfontein specimen.

It seems, therefore, that the characteristics of the Sterkfontein specimen can only be explained as a by-product of intelligent hominid behaviour. As

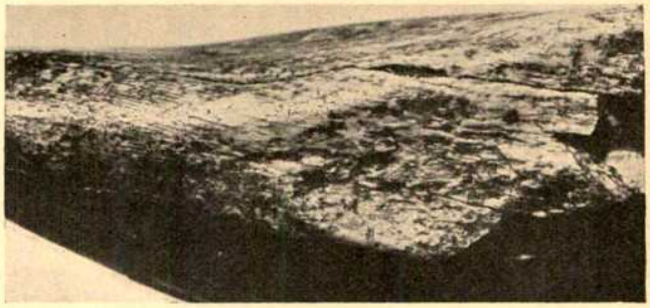

Fig. 4. Enlarged view of a portion of the Sterkfontein specimen showing a shallow oval hollow (near centre) with completely unsmoothed surface partly surrounded by polished surface

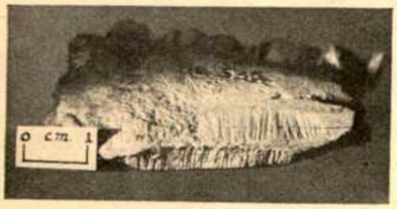

Fig. 5. Fragment of fossil bovid mandible, from Sterkfontein extension site, which had been gnawed by rodents

such it is the first clear-cut example of the utilization of bone from the Sterkfontein area and probably the best at present known from the australopithecine era. It certainly appears to be clear evidence of the artificial utilization of bone at that time-level. Since this specimen came from the same breccia which has yielded the stone artefacts from this site, it must presumably for the present be attributed to the makers of the latter. In my opinion[1,2], *Australopithecus* is unlikely to have made the stone artefacts—it seems more likely that *Telanthropus* was responsible. Probably, therefore, the latter was also responsible for the bone tool. It is not impossible, in view of the evidence accumulated by Dart, that *Australopithecus* had an 'osteodontokeratic' but not an established stone culture, but that *Telanthropus* did have the latter. If this is the case, it is possible that the Sterkfontein bone tool, but not the stone industry, was of australopithecine origin. It is, in any event, interesting to note that the specimen came from the back portion of the cave, as it was at the time of accumulation, among a mass of bones. The remainder of the deposit at that level has a much smaller proportion of bone.

I am indebted to the director of the Archæological Survey and to Dr. R. Mason of the same organization for the loan of Natufian bone implements from Mount Carmel for comparative study.

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[1] Robinson, J. T., and Mason, R. J., *Nature*, **180**, 521 (1957).

[2] Robinson, J. T., *Leech*, **28**, 94 (1958).

[3] Singer, R., *Amer. Anthrop.*, **58**, 1127 (1956).

CHEMISTRY IN THE PRESERVATION OF ANTIQUITIES

AT a joint meeting of Sections B (Chemistry) and H (Anthropology) held during the York meeting of the British Association, Dr. A. E. A. Werner and Mr. R. M. Organ of the British Museum Research Laboratory discussed the subject of chemistry in the preservation of antiquities.

Dr. Werner said that the application of the chemist's specialized knowledge to the problems that arise in the preservation of antiquities may be taken to involve, first, the recognition of the symptoms of deterioration exhibited by antiquities and the realization of the ultimate causes for this deterioration expressed in terms of the physical and chemical structure of the object, and, secondly, the evolution of sound methods of conservation based on theoretical considerations and tested by practical experimentation—preferably, of course, on trial pieces or objects of minor importance specially acquired for the purpose.

In the past, the methods used in the conservation of antiquities were largely of an empirical nature and the materials used were limited to those of natural origin which approximated most closely, in their chemical and physical properties, to the needs of the particular work in hand. Typical examples of such materials are waxes such as beeswax and paraffin wax, natural resins, and animal and vegetable glues. However, in the past three decades or so, there have been remarkable advances in high-polymer chemistry which have led to the introduction of many new synthetic materials, possessing a combination of chemical and physical properties not normally found in materials of natural origin. The assessment of the potential value of these synthetic materials in the elaboration of more reliable methods for the preservation of antiquities was discussed with special reference to specific problems in the preservation of antiquities of an organic nature.

One outstanding problem is the question of the most suitable method for the treatment of wooden objects which are obtained from excavations in a so-called water-logged condition. Old water-logged wood may have a water content of more than 100 per cent of the dry matter in the wood, and its actual physical state will depend upon the degree of degradation, that is, the extent to which the cellulosic cell-wall structure has broken down. If this has reached an advanced stage, the wood will be quite soft, almost like cheese, and will have a very low mechanical strength. In considering the problem of stabilizing old water-logged wood, there are two factors to be considered. The first involves the actual removal of the large excess of water without causing serious deformation of the wood, and the second involves the consolidation of the wood to restore sufficient mechanical strength so that it can be handled with ease.

If the water is allowed to escape by ordinary evaporation, surface tension forces exerted on the weakened cell walls will cause them to collapse. Hence, special techniques have been evolved. One such technique is the so-called alum process, in which the wood to be treated is immersed in a supersaturated solution of alum at a temperature of about 95° C. until complete impregnation is achieved. The idea behind this method is to replace the water by a solid, alum being used because it can be dissolved in a very small amount of water. A more refined method is the use of the well-known biological technique for drying tissues by immersion in successive baths of ethyl alcohol followed by immersion in baths of ethyl ether. If the final ether bath contains a resin such as dammar in solution, the resin will remain after evaporation of the ether to stabilize the wood structure. This is a relatively expensive process and involves a serious fire risk, so that it is confined, in practice, to the treatment of small objects, where it has been found to give excellent results. The well-known technique of freeze-drying can also be applied. The water is frozen to ice which is evaporated from the wood under vacuum, so that any tendency for the cell-wall structure of the wood to collapse due to exertion of surface tension of *liquid* water is avoided. Experiments made in the British Museum have shown, however, that the results are unreliable, and the method is very slow and time-consuming, since it requires more or less constant supervision unless an expensive automatically controlled refrigerating unit is installed.

Since none of the above techniques may be regarded as being uniformly successful, experiments have been in progress in the British Museum Laboratory based on the use of the synthetic polyethylene glycol waxes. These waxes, although possessing the characteristic physical properties of waxes, have the rather unexpected property of being soluble in water. They are available in a polymeric series ranging from soft waxes rather like 'Vaseline' to hard waxes similar to the typical paraffin waxes. It has been found that the wax of average molecular weight 4,000 (the actual material used is known by the trade name of 'Carbowax 4000' produced by Union Carbide Chemicals Co.) is suitable for the treatment of water-logged wood. The new technique which has been evolved consists in immersing the wooden object in a 12 per cent aqueous solution of the 'Carbowax 4000' at room temperature and slowly increasing the temperature to *c.* 60° C. over a period of many weeks. The water in the wood slowly diffuses out and is replaced by the wax. During the period of treatment, the solution is allowed to evaporate so that at the end the wooden object is lying immersed in molten 'Carbowax'. This technique is particularly suitable for wood which has suffered a considerable degree of degradation while in the water-logged state and is in a spongy condition.

If the structure of the water-logged wood has not suffered too severely, and still retains a certain degree of structural strength, an alternative method of treatment can be adopted. The wooden object is allowed to dry out slowly by being placed under conditions of gradually decreasing humidity. Under these conditions, the wood will dry without suffering distortion apart from a slight flaking of the surface layer. Consolidation is achieved by impregnation with an epoxy resin which is brushed on to the wood as a mobile liquid which readily permeates the wood, where it solidifies *in situ* at room temperature, thus conferring upon the wooden object the necessary mechanical strength. These epoxy resins, which have the highly desirable property of setting to a solid without undergoing appreciable contraction, are of general application as agents for the impregnation of wooden antiquities which are in a fragile state, for example, wooden objects which may have been severely weakened as the result of attack by insects.

In the case of leather objects which may be recovered from excavation in a fragile state as the result of being water-logged, or in a brittle condition due to excessive desiccation, immersion in molten polyethylene glycol wax of grade 1,500 at a temperature of about 45° C. affords a simple method of preservation. The hydrophilic wax removes the water and consolidates the water-logged leather, whereas in the case of the brittle leather, the absorption of the polyethylene glycol wax restores to a marked degree the flexibility of the leather so that it can be handled with ease and, if necessary, reshaped without fear of breaking. Two other synthetic waxes which have proved of value in the formulation of a wax mixture for the surface protection of antiquities are the microcrystalline waxes which, owing to their special physical structure, are superior to the conventional paraffin waxes and the hard polyethylene waxes of relatively high melting point.

Another field in which new synthetic materials have found extended use in conservation is that of adhesives. When considering the use of adhesives in the restoration of fragile antiquities, the single factor which is of major importance is the question of the amount of shrinkage which can occur when an adhesive sets ; if this is large, strains are set up which may weaken the bond or cause distortion of the bonded complex. In this respect the most suitable adhesives are those based on epoxy resins ; these represent a class of adhesive which sets by chemical reaction *without* the loss of any volatile material.

The presence of soluble salts which have been absorbed by porous objects while buried in the earth prior to their excavation—for example, Egyptian ostraka—may be the latent cause of deterioration. When such objects are exposed to atmospheric conditions in which there are large fluctuations in the relative humidity, these salts tend to be transported to the surface where they crystallize out, thus obscuring the surface and, in the course of crystallizing, causing the surface layer to flake away ; in the case of ostraka, this would result in the loss of the actual writing. These soluble salts can be removed by the simple process of washing in water ; but, before carrying out the washing, it is necessary to consolidate the surface of the object in order to prevent any flaking away of the surface. This consolidation can be readily achieved by the use of a special soluble modified nylon—a material produced by Imperial Chemical Industries, Ltd., under the trade name 'Maranyl soluble nylon polymer *C* 109/*P*'. This material is soluble in either methyl alcohol or ethyl alcohol, and when a 5 per cent solution in one of these solvents is brushed on to the object prior to washing, it deposits a surface film which is not only permeable to water (thus permitting elution of the soluble salts), but also possesses a marked degree of flexibility so that it does not exert any undue contractile force on the frail surface layers. This material also possesses adhesive properties which render it very suitable for the reattachment of flaking paint on wall paintings. It was used, for example, in the treatment of a fragment of a tempera wall painting from a tomb at Thebes of the XVIIIth Dynasty in which the paint layer was tending to blister badly. A warm 5 per cent solution of soluble nylon was brushed over the areas of flaking paint and gentle pressure applied. The alcoholic solution, having a much lower surface tension than an aqueous solution, readily flows into the minute cracks in the blisters and spreads out underneath the flakes of detached paint, drawing them back into position ; in this way a secure bond was formed between the reattached paint and the ground. Furthermore, the surface film has a matt appearance so that it does not leave an æsthetically undesirable sheen on the treatment areas of the painting.

Mr. Organ dealt with the problems that arise in the preservation of bronze antiquities. He first described the causes of corrosion and the build-up of the corrosion layers. Metallographic examination shows that in the majority of bronze alloys the metal consists of a two-phase system. Prior to excavation, these contiguous phases have often been in contact with water which had percolated through the soil and contained dissolved salts. An electrolytic system is thus set up in which one of the two phases corrodes to form insoluble salts which are deposited on the surface of the object in the form of minerals which comprise the well-known 'patina' characteristic of antiquities Cross-sections of a corroded bronze were shown in illustration

The occurrence of the so-called 'bronze disease' in museums is connected with the presence of cuprous chloride as a component in this mineral structure This material not only reacts with moisture and oxygen in the air to form basic cupric chloride (which is the light green material that appears as the characteristic spots of bronze disease) but also attacks the underlying bronze with the formation of cuprite Hence action directed towards preserving a bronze object must be aimed at nullifying the activity of this particular salt

In those cases where it is desirable to retain the mineral patina on a bronze, the reactivity of the cuprous chloride may be overcome by the use of special chemical reagents, namely, (*a*) sodium sesquicarbonate solution or (*b*) specially prepared solid silver oxide

In the first method the object is immersed in successive solutions of sodium sesquicarbonate, which has little visible effect on the patina, but is sufficiently alkaline to neutralize the hydrochloric acid produced when the cuprous chloride is slowly converted into cuprite $2\,CuCl + H_2O \rightleftharpoons Cu_2O + 2HCl$ The second technique, involving the use of silver oxide, was specially developed in the British Museum Laboratory for the treatment of objects which for some particular reason cannot be immersed in an aqueous solution, for example, a bronze object inlaid with enamel-work The aim of this procedure is to seal off the corroding areas containing cuprous chloride by applying over them a layer of silver oxide powder which reacts to form an impervious layer of silver chloride

When it is desirable to remove patina, which may be not only unsightly but also concealing valuable detail on the object, the various layers of mineralization can be successively removed by chemical means First, the green basic carbonate is dissolved by immersing the object in alkaline Rochelle salt, then the cuprite is destroyed using dilute sulphuric acid, and, finally, the cuprous chloride layer is removed by cathodic reduction in alkaline solution When this treatment has been completed, there will still be residual chlorides remaining in the porous metal, these must be removed completely if the object is to remain in a stable state under normal museum conditions This can only be successfully achieved by a special process of intensive washing in many successive baths of distilled water The progress of the washing is followed by measuring the electrical conductivity of the successive baths of wash-water until it falls to a minimum and the absence of chloride is established It has recently been found that this process, which used to take up to eight months for completion, can be speeded up by a factor of as much as ten by the use of ultra-sonics

When the mineralized layers are removed, the object may sometimes be in such a frail state that some form of mechanical support is necessary In the past, material such as wood or plaster and adhesives such as shellac and nitrocellulose were pressed into service *faute de mieux* An improved technique was recently developed in the British Museum Laboratory using a suitable epoxy resin which can be supplied as a liquid which sets *in situ* to form a reinforcement This material is ideal for the purpose because it adheres well to the metal, sets without shrinkage so that no contractile stresses are exerted on the fragile object, and it is transparent so that no details of design are obscured This technique was successfully used to strengthen a unique silver hanging bowl excavated at St Ninian's Isle, Shetland, which, after removal of corrosion products, was as thin as an egg-shell

A E A WERNER

GENETICS AND THE ORIGIN OF SPECIES

TO assess the magnitude of Darwin's contribution to biology one hundred years after the publication of "The Origin of Species", it is necessary to recognize that Darwin developed his ideas in a very different climate of biological thought from our own Darwin's recognition of the dynamic nature of species was made at a time when species were regarded as the static products of natural creation

Species, as aggregates of individuals subject to variation and constantly being replaced by those of their progeny which escape from the hazards of their environment, represent a concept which we owe to Darwin and which still lies behind our knowledge of evolution

Modern theories of genetics have sprung from Mendel's demonstration of the particulate nature of inheritance and the subsequent discoveries that the hereditable determinants, or genes, are located in the chromosomes The idea that genes are subject to mutation and liable to re-assortment at meiosis represents the crude mechanism of the variation on which natural selection must operate, but behind this lies the more fundamental aspect of gene evolution and the biochemical mechanism of their operation

If the symposium in Sections D (Zoology) and K (Botany) of the British Association at the recent York meeting gives an insight into modern evolutionary thought, it is clear that geneticists are at present largely concerned with the manner of gene action and the process of modification in genetic constitution which selection induces Several speakers pointed out that the precise effect of a gene is modified by the genetic environment of the gene so that successful species come to possess a highly integrated gene-assemblage As Prof K Mather (Birmingham) emphasized, the main features of an organism affected by selection are controlled by swarms of genes acting together The effects of separate genes are balanced, and selection shifts the balance, giving gradual and not jerky evolutionary change Moreover, it is only in this way that we can understand how an organism can achieve the complex selection-advantage we find, for example, in mimicry, where a strong degree of visual similarity with the model must be obtained before selection will operate In the case of the African butterfly, *Papilio dardanus*, in which the female mimics several models, Dr P M Sheppard (Liverpool) described how the range of variation in mimic characters of the progeny of hybridization of geographical races indicated polygenic control Dominance of mimic features has been selected, so that hybrids between races which naturally meet ensures mimicry in offspring, in hybridization of races which do not naturally meet, this dominance is lost, but reasserts itself when replaced in its original genetic environment by progressive backcrossing to the race which originally possessed it

Re-adjustment of the gene-complex under the pressure of selection will account not only for change within a species with the passage of time, but also for divergence of parts of a species Any tendency for genes not to diffuse throughout all the members of a species will encourage the development of restricted gene-complexes In introducing the symposium, Prof J Heslop-Harrison emphasized that these barriers to gene-flow, or isolating mechanisms, are of several types

Physiological isolation by hybrid failure or sterility is the main genetic criterion by which species status is recognized, and this may be attained at a single evolutionary step in cases of polyploidy

Dr R Riley (Plant Breeding Institute, Cambridge) directed attention to the high frequency of polyploidy in plants, where successful polyploids usually arise by the combination of genomes, which, even if derived from the same species, are sufficiently different to allow diploid behaviour (chromosome pairing) to be established at meiosis Dr Riley showed how cytogenetical techniques had allowed the three genomes present in common wheat, which is hexaploid, to be identified as those of *Triticum monococcum*, *Aegilops speltoides* and *A squarrosa* By taking advantage of chromosome deficiencies, the mechanism controlling genetic isolation in wheat had been located and the way opened for hybridization with other cereals

Isolation by breeding preference was discussed by Dr A J Bateman (Christie Hospital and Holt Radium Institute, Manchester) Experiments with the fly *Drosophila*, where a choice of mating partner is offered, indicate that, for example, body-colour mutants influence preference Field observations of nesting pairs of birds where a plumage-colour variant is present have shown similar preference to operate in natural populations Constancy of pollinator in plants must play a similar part as, for example, between the two campions, *Silene dioica* and *S alba*, which are respectively bee- and moth-pollinated

In both outbreeding plants and animals, however, spatial isolation by ecological or geographical factors is the most widespread external mechanism which allows initial divergence either by chance restriction of genes in limited populations, or because ecological conditions differ between populations or their parts The nature of soil preference and importance of competition were discussed by Dr C D Pigott (Sheffield), who described the manner of elimination of *Vaccinium vitis-idaea* from mixed populations with *V myrtillus* and occasional hybrids, by reduction in grazing pressure after enclosure and exclusion of sheep from upland oak-woods

That divergence can precede isolation, however, is evident from experiments with *Drosophila* described by Dr J M Thoday (Sheffield) By disruptive selection (elimination of the mean phenotypes and retention of extremes) within a single breeding population over several generations, a steady trend of divergence of the extremes is produced Furthermore, experiments, in which the most extreme individuals are those used for breeding, demonstrate that this difference can be maintained

Experimental studies of this type demonstrate very clearly that evolution is no longer a theory propounded by Darwin but an indisputable fact

C D PIGOTT

OBITUARIES

Dr. Louise Pearce

DR LOUISE PEARCE, former associate member of the Rockefeller Institute, who had worked there from 1913 until 1951, died in New York City on August 9 at the age of seventy-four years Having graduated M D at the Johns Hopkins University in 1912, she began in 1913 her chemotherapeutic studies in association with W H Brown of the Institute A few years previously Ehrlich had had great success in the treatment of disease, including syphilis, with organic arsenicals In collaboration, these two workers studied experimentally the effect of arsenical compounds on laboratory infections in animals with the parasite causing African sleeping sickness One compound of this series, namely tryparsamide, prepared by Jacobs and Heidelberger in 1919, proved very effective against rabbit syphilis and was able to save the lives of animals infected with the pathogenic African trypanosomes Tests on the response of the human disease to this new substance were now urgently required Louise Pearce, of resolute character and endowed besides with great physical strength and vigour, was chosen to go out to the Belgian Congo in 1920, where thousands of natives were dying of the disease, and there carried out the tests at great personal risk

The success of the new drug was soon obvious and, as Peyton Rous has written, "she brought about one of the most shining and spectacular of the early purposeful achievements of the Institute, the conquest of sleeping sickness" Tryparsamide owes its importance to the fact that it can reach the cerebrospinal fluid in considerable concentration and has the capacity to affect trypanosomes in the central nervous system For this work Dr Pearce was awarded in 1953 the King Leopold II prize of 10,000 dollars and made an officer of the Royal Order of the Lion, having previously received the Belgian Order of the Crown Her colleagues, W A Jacobs, M Heidelberger and W H Brown, were also honoured With the last-named she discovered a rabbit cancer, known as the Brown–Pearce carcinoma, which could be transplanted to other rabbits and has proved of considerable value experimentally The virus causing rabbit pox was another of her discoveries

She was keenly interested in medical education and served during 1946–51 as president of the Women's Medical College of Philadelphia Besides her successful mission to Africa she served as visiting professor of medicine at Peiping Union Medical College during 1931–32 Her interests were wide and embraced many aspects of national and international life As an officer of a number of organizations concerned with the study of bacteriology, medicine, tropical medicine, cancer and other diseases, she proved a good citizen of the world

During her life-time she was awarded a number of honorary degrees and prizes Her monograph "The Treatment of Human Trypanosomiasis with Tryparsamide", published by the Rockefeller Institute, is a classic

J D FULTON

Dr E S Duthie

DR EDWARD STEPHENS DUTHIE died on June 9 at the age of fifty-two He was an experimental and clinical pathologist with an exceptional range of talents Born in Kilkenny, he won a sizarship in mathematics to Trinity College, Dublin, and graduated in arts, medicine and science He began biological research under Prof J B Gatenby in Dublin and continued under Prof A E Boycott at University College Medical School, London, where he went as Graham Scholar in 1933 His published work during this period was concerned mainly with the mechanism of glandular secretion While convalescing from tuberculous pleurisy in Italy he wrote a paper on the origin, development and function of the blood cells in certain marine teleosts

After a brief interlude as assistant pathologist at the University of Sheffield, he joined the staff of the Dunn School of Pathology, Oxford, and collaborated with Chain in a study of 'spreading factor', which they identified as hyaluronidase Duthie was unfit for military service during the War so he worked as hospital pathologist at Northampton until he was recalled to Oxford to help Sir Hugh Cairns, he organized and took charge of all the chemotherapy at the Radcliffe Infirmary and at the Military Hospital for Head Injuries His development of penicillinase, his work with Chain on the theory of action of penicillin and his demonstration of the influence of pH on the activity of streptomycin, have all contributed to the rapid progress of chemotherapy

Duthie took charge of the Serum Department of the Lister Institute in London in 1946 and worked on serum and bacterial proteases and their inhibitors In 1948 he was appointed deputy director of pathology at Southampton, becoming director in 1952 During the past ten years he studied various products of the staphylococcus His crowning achievement was the purification of coagulase—the first blood-clotting substance to be purified

Duthie's integrity, sympathy and kindness were apparent to all who met him, his friends knew his generosity, his concern for refugees and all who were oppressed, his appreciation of art and music and his courage and cheerfulness in the face of prolonged ill-health

CHARLES H LACK

Mr John Cecil May, C M G , O B E

BY the death on September 10 of J C May, director of the Empire Cotton Growing Corporation, tropical agriculture has lost one of its wisest and most distinguished administrators of agricultural research His background of geology and forestry at Oxford, and of the administrative service in Nyasaland and Tanganyika, was singularly appropriate for the development of his life's work in an independent corporation engaged in research in tropical territories His judgment and enthusiasm were largely responsible for the high standard of recruitment to the Corporation's service, and his sympathy and understanding for the welfare of his staff in the diverse circumstances in which they work He understood the needs and difficulties as well as the responsibilities of government departments, and his breadth of interest was the foundation of the co-operation between government officials and the research staff of the Corporation that has been so fruitful in the extension of the cotton crop in African territories His vision and grasp of practical needs and possibilities enabled the Corporation to continue to provide staff for the Sudan when the Republic of the Sudan was established In planning the British contribution to technical services in the new Africa that is emerging, his counsel will be sorely missed

J B HUTCHINSON

NEWS and VIEWS

International Red Locust Control Service

THE last plague of the red locust, *Nomadacris septemfasciata* Serville, lasted from 1930 until 1944 and affected most of Africa south of the equator Field investigations by British, South African and Belgian scientists revealed comparatively small outbreak areas in Northern Rhodesia and Tanganyika In 1941 A P G Michalmore set up headquarters in Abercorn, Northern Rhodesia, and began preventive control of these areas, in 1945 H J Bredo became director of the International Red Locust Control Service This Service was established by international treaty in 1949 and the first decade of the treaty was completed on August 5 this year At first, the idea was to watch for any upsurge of locusts in the outbreak areas and then to arrange control measures, but it became clear that events moved too quickly and the Service had to be constantly ready to attack Even so, swarms escaped from the outbreak areas in most years until operational research, mainly by Haydn Lloyd, led to the design of fully effective methods of control, using very light aircraft In 1955 there occurred the largest upsurge ever recorded, it was completely controlled No swarms have escaped since 1954

Dr D L. Gunn, C B E

DURING the period 1952–59 the director of the International Red Locust Control Service was Dr D L Gunn Educated at the High School and the University College, Cardiff, he was then for seventeen years at the University of Birmingham, first as assistant lecturer and finally senior lecturer in zoology There he became known for researches on the temperature and humidity relations of insects and he collaborated with Dr Gottfried Fraenkel in "The Orientation of Animals" (Oxf Univ Press) Towards the end of the War, he was seconded to Kenya to study the behaviour of desert locusts in swarms, in relation to aircraft spraying, and in 1945 with Douglas Yeo and a team from the Chemical Defence Experimental Establishment, Porton, he carried out the first attacks on adult locusts in Africa that used liquid insecticide sprayed from aircraft In 1946 he became the first principal scientific officer of the Anti-Locust Research Centre, then newly separated, under Dr B P Uvarov, from the Commonwealth Institute of Entomology, and was responsible for starting and building up its research programme, both in the Centre laboratory and extra-murally in universities In 1947, jointly with H A F Lea (now chief locust officer of the Union of South Africa), he was responsible for successful aircraft spraying experiments against the red locust in Tanganyika In 1950 he did field experiments in Somaliland and the Sudan which resulted in the complete replacement of wet bait by dry bait for controlling the desert locust with great economies in cost In 1952 he was appointed director of the International Red Locust Control Service , in the following years, this Service was completely reorganized, made effective, and cheapened to about half its earlier maximum annual cost Dr Gunn was appointed C B E in 1958 and he now leaves Africa to become director of the Tea Research Institute of Ceylon

Mr C du Plessis

THE Council of the International Red Locust Control Service has invited Mr C du Plessis to become director, in succession to Dr Gunn Educated at Oudtshoorn and at Grey University College, Bloemfontein, he lectured in zoology at Grootfontein College of Agriculture for six years and in entomology at Glen for four years before beginning full-time research on stalk-borer at Kroonstad Soon after the red locust plague reached South Africa, he began research under Prof J C Faure, publishing mainly in the science bulletins of the Department of Agriculture, and becoming increasingly involved in control as well In 1944, locust research, locust control, and administration, were combined under the newly enlarged post of chief locust officer, to which post Mr du Plessis was appointed He was responsible for containing within the outbreak areas a prolonged upsurge of the brown locust from 1948 until 1954 , during this period, both control methods and administration were completely revolutionized Representing South Africa on the International Red Locust Control Service Council for many years, he was elected president in 1954 in succession to Mr G B Beckett, then Member for Agriculture in the Northern Rhodesia Government He retired from the post of chief locust officer in December 1958

Theoretical Mechanics at Southampton :
Prof B Thwaites

A THIRD chair of mathematics, with special reference to fluid mechanics, has been created at Southampton The first holder of the chair will be Dr Bryan Thwaites Dr Thwaites, after graduating in Cambridge with first-class honours in mathematics, spent three years in the National Physical Laboratory and was then appointed lecturer at the Imperial College of Science and Technology in the Department of Aeronautical Engineering In 1951 he became assistant master at Winchester College but maintained his contact with university teaching and research as visiting lecturer in fluid mechanics at the Imperial College Dr Thwaites has been a member of the Performance Sub-Committee of the Aeronautical Research Council and is at present a member of the Fluid Motion, Engine Aerodynamics and Laminar Boundary Layer Panels of that Council He is chairman of the Aerofoil Theory Panel and editor of "Incompressible Aerodynamics" due to be published this year His name is familiar in the form of the Thwaites flap and with his engineering interests it is expected that his appointment will strengthen the already existing ties between mathematics and engineering in the University of Southampton Dr Thwaites's wide cultural and teaching interests will be particularly welcomed in the rapidly expanding University of Southampton

Electrical Engineering at Southampton :
Prof L G A Sims

DR SIMS, head of the Electrical Engineering Department and senior lecturer in electrical engineering in the University of Southampton, succeeded the late Mr P G Spary in 1952, and he has now been made professor in the University Dr Sims studied under the late Prof William Cramp at the University of Birmingham, graduating with first-class honours and a Bowen Research Scholarship in 1924 He obtained his M Sc with an award of a research prize He joined the Research Laboratories of the General Electric Co , Ltd , under the late Sir Clifford Paterson. Later he joined the lecturing staff of the University of Birmingham, and although primarily concerned with power engineering, and founding the first electronics laboratory, he was associated with the first successful television reception in Birmingham received from the original London Baird transmitter Dr Sims initiated and directed researches at Birmingham upon the incremental properties of magnetic steels In 1936 he was appointed head of the Electrical Engineering Department of the Northampton Polytechnic in London On the power utilization and supply side, Dr Sims was one of the first engineers in Britain to be interested in energy storage with the a c system and initiated research work upon electro-thermal storage methods He has held senior teaching appointments in Government Service both at the Royal Naval College, Greenwich, and the Royal Aircraft Establishment, Farnborough During the session 1957–58 Dr Sims was chairman of the Institution of Electrical Engineers, Southern Centre His main ambition is that he and his staff shall advance the prestige of the already well-known Electrical Engineering Department in the University of Southampton, and liaison work with large industrial concerns in different parts of Britain together with new electrical courses may lead to a system of postgraduate scholarships in electrical engineering by the time of the University centenary in 1962

Physics at the University College of North Staffs :
Prof D J E Ingram

DR D J E INGRAM has been elected to the chair of physics at the University College of North Staffordshire, in succession to Prof F A Vick, who has become deputy director of the Atomic Energy Research Establishment, Harwell (*Nature*, 183, 861 , 1959) Dr Ingram was reader in electronics at the University of Southampton, where he went in 1952 to work with Prof E E Zepler, now president of the British Institution of Radio Engineers He took a first in physics at Oxford in 1948 and worked for three years under Prof B Bleaney on magnetic resonance At Southampton he extended his work on microwave spectroscopy, gathering together a team of physicists, chemists and electronic engineers, which has applied the techniques of electron resonance to a variety of problems in physics and chemistry This work has been particularly fruitful in studies of metallo-organic compounds, such as the hæmoglobin molecule, in the investigation of breakdown processes resulting from ultra-violet irradiation and in detection of free radicals in various forms of carbon Dr Ingram has also been concerned with the study of maser and mavar problems, and with the use of electron resonance in applied electronics He is the author of two books on the applications of microwave spectroscopy to physics and chemistry, and has been one of the instigators of the formation of the Radiofrequency Spectroscopy Group

Chair of Applied Mathematics at Cardiff:
Prof P T Landsberg

DR P T LANDSBERG, who has been appointed to the newly created chair of applied mathematics at Cardiff, came to Britain from Germany in 1939 He followed his bachelor's degree in the University of London by a master's degree in the field of quantum mechanics, and in 1947 he became one of the early members of Dr T E Allibone's staff at the Associated Electrical Industries Research Laboratory, Aldermaston He participated in the semi-conductor interests of the Laboratory, concentrating on the theory of electrical barriers The generosity of the Laboratory enabled him also to work at the same time for a Ph D degree under Prof H Jones on the effects of electron collisions on the soft X-ray emission bands of sodium, this investigation showed that there were long-range correlations among the electrons, resulting in an unexpected screening of the Coulomb interactions Since 1950, Dr Landsberg has been a lecturer in natural philosophy at Aberdeen, where his teaching interests have ranged from first-year practical classes to statistical mechanics at an advanced level In 1956, together with his pupil, Dr I E Farquhar, he helped to re-open the subject of the quantum statistical ergodic and *H* theorems, which were thought to have been proved by von Neumann in 1929 and later improved by Pauli and Fierz, by showing that they were based on an erroneous argument Also in 1956, Dr Landsberg published a notable paper on the foundations of thermodynamics in "Reviews of Modern Physics", and has a book appearing shortly in the same field He has maintained his interest in semiconductors, where his most recent paper, with his pupil, Dr A R Beattie, shows that electron collisions can play the dominant part in limiting the life-time of excess carriers in indium antimonide From the agreement between his theory and the experimental findings, it appears that this substance may be the first semiconductor in which the life-time has been made to approach its theoretical maximum

Festschrift for R E Snodgrass

THE whole of Vol 137 of the Smithsonian Miscellaneous Collections (Studies in Invertebrate Morphology Pp v+416+49 plates Washington, D C Smithsonian Institution, 1959) consists of a series of seventeen original articles by well-known entomologists from many parts of the world under the general title of "Studies in Invertebrate Morphology", and is published "in honor of Dr Robert Evans Snodgrass on the occasion of his eighty-fourth birthday, July 5, 1959" It is hard to think of R E Snodgrass as having reached this score He is the tough wiry Mark Twain type of American, admirably depicted in a frontispiece made last year, his ready and slightly caustic wit remains unimpaired, and he is still turning out first-class work on the morphology of insects The book contains a sympathetic biographical chapter by Dr Ernestine B Thurman, illustrated with some of the highly professional comic drawings that Snodgrass produced in his early days The scientific articles maintain a high standard throughout and many of them demonstrate the widespread influence exerted by Snodgrass as a morphologist But Snodgrass has always taught that "morphology must be intimate with function" and it is appropriate that there are several good papers on insect physiology There is plenty of good material in the volume, but it is fitting that the best paragraphs of all (pp 17–18) should be those in which R E Snodgrass himself resumes his outlook on life in a few well-chosen words

Sir Dorabji Jamsetji Tata (1859–1932)

THE leading architect in the intellectual and industrial renaissance of India Sir Dorabji Jamsetji Tata was born at Bombay on August 27, 1859, and was educated at Gonville and Caius College, Cambridge, and at the University of Bombay, where he graduated in 1882 On his father's death, he became head of the company, Tata and Sons, the largest industrial concern in India In 1911 he established the Tata iron and steel works at Jamshedpur, and in the same year founded the Indian Institute of Science at Bangalore to prepare young Indians for the direction of modern large-scale industries and for industrial research He was knighted in 1910 and served as president of the Indian Industrial Conference in 1915 A great philanthropist who rendered help without distinction of caste or creed, he gave £25,000 to the University of Cambridge in 1920 for the equipment of laboratories in the School of Engineering (he was elected an honorary fellow of his college in 1922) In 1931 he created as a memorial to his wife the Lady Tata Memorial Trust for research in any part of the world into diseases of the blood, and for work in India for the alleviation of human suffering The last of his house, he died at Kissingen in Bavaria on June 3, 1932 and was buried in the Parsi cemetery at Brookwood, Woking In 1945 the Tata Memorial Hospital was erected in the city of his birth

National Science Foundation Review of Research and Development

IN a statement on Research and Development and Economic Growth (issued as No 13 by the U S National Science Foundation in its Reviews of Data on Research and Development), Dr A T Waterman said that the Foundation's studies indicated that national research and development effort currently stood at more than 10 thousand million dollars, compared with less than 500 million dollars before the War, and had doubled since 1954 In terms of performance, industry accounted for about 70 per cent, Government about 20 per cent, and universities and other non-profit institutions for the rest in terms of finance Government accounted for rather more and industry for somewhat less than half Dr Waterman stressed the long-term significance of the economic implications of research and development, and besides the beneficial results which war expenditure on military research and development might have on the civilian economy, research and development could stimulate the under-developed economies of other countries It was the key to the two great challenges of the future the increasing opportunity to achieve our own potential growth and expansion and the urgent need to co-operate with the great under-developed countries of the world Of the 10 thousand million dollars currently expended on research and development, only about 6 per cent was on basic research. In making a strong plea for more support of basic research, especially in colleges and universities, Dr. Waterman said that this would ultimately reduce development costs by indicating the best fields of research. The Federal Government was supporting research in academic institutions but wished to see industry increasing its support for such research as well as its support of basic research in its own laboratories. Industry was the largest employer of scientific personnel, employing in January 1957 nearly two-thirds of the scientists and engineers in the United States, including 528,000 engineers, 152,000 scientists and 58,000 administrators of such activities, about a third of whom were engaged on research and development.

Scientific and Technical Personnel

THE National Science Foundation of the United States has announced that at the request of the Bureau of the Budget it will be responsible for establishing and maintaining a programme of national information on scientific and technical personnel. This will cover their training and utilization, compensation levels, supply and demand, and other related data. The Foundation will organize the register, co-ordinate and analyse all information gained, and ensure that the findings be made public. Much of the information recommended will be produced by extending existing statistical records. Other projects will have to be initiated to meet the objectives of the programme. The decision of the Bureau to ask the Foundation to organize the register arose from recent recommendations of an advisory panel on 'Scientific Manpower Data Requirements'. The panel recommended a programme of fifteen projects, of which the most urgent were considered to be: first, an identification of scientific and technical occupations; secondly, a periodic survey of organizations employing scientific and technical personnel; and finally, a periodic study of the demand outlook for various categories of scientific and technical personnel in each major activity. The last item would include analyses of employment and production growth trends and also the changing roles of particular classes of scientific and technical personnel.

Productivity Measurement in Great Britain

A REPORT by T. E. Easterfield (Department of Scientific and Industrial Research. Productivity Measurement in Great Britain: a Survey of Recent Work. By T. E. Easterfield. Pp. ii+79. London: Department of Scientific and Industrial Research, 1959) attempts to survey recent or current British studies of productivity measurement at the level of the individual factory, together with such other related work as seems particularly illuminating. Studies based on overall statistics of whole industries are included only where they throw light on the problems of more detailed studies. The report first briefly discusses the main purposes of productivity measurement: overall economic analysis and planning; planning, target setting and the forecasting of requirements of industries or firms; the spotlighting of cases that stand out by reason of high (or low) productivity; and investigation of other factors that may affect productivity, and their relative importance. The main sections are the problem of multiple inputs; the problem of multiple outputs; the study of factors affecting productivity and the translation of results for practical application.

Education in the Commonwealth

A PAMPHLET, "Commonwealth Education: The United Kingdom Contribution" (prepared for the Commonwealth Relations Office and the Colonial Office by the Central Office of Information. Text by Duncan Crow. Pp. 68+4 plates. (London: H.M. Stationery Office, 1959.) 2s. 6d.), gives an impressive picture of what the United Kingdom is already doing in this field, to which, in the twelve years April 1946–March 1958, Britain contributed under the Colonial Development and Welfare Acts £35 million in grants and loans, of which £16 million were for primary and secondary education, £6 million for technical and vocational education and £13 million for higher education. The pamphlet brings together, moreover, facts about an effort which embraces also what is being done through the British Council for the welfare of the 7,000 odd full-time Commonwealth students in the United Kingdom, some of whom are numbered among the 728 training as teachers in the United Kingdom and for the teaching of English in the Commonwealth. There is a section dealing with the Colombo Plan trainees and with the 6,566 Commonwealth students in United Kingdom technical colleges, and another with the remarkable growth of Commonwealth universities between 1938 and 1957, in which period the number of institutions has increased by 50 per cent, their teaching and research staff has trebled and full-time students have nearly quadrupled. No attempt is made to indicate the total cost to Great Britain, and, impressive as it is, the pamphlet shows clearly enough how much more remains to be done and the opportunities which interchange schemes, for example, offer for expansion.

Public Library Statistics in Great Britain

"STATISTICS of Public (Rate Supported) Libraries in Great Britain and Northern Ireland 1957–1958" (Pp. 33. London: Library Association, 1959. 7s. 6d.) gives the number of public library authorities in the United Kingdom on March 31, 1958, as 569, serving an estimated population of 51,597,000 and holding a stock estimated at 68,600,000, approximately 16 per cent being reference stock. Issues for home reading are estimated at about 431,863,000, an increase of 12,435,000 on 1956–57, and total expenditure was £17,522,000 compared with £15,906,000 in the previous year, of which £4,254,000 and £3,863,000 respectively were expenditure on books. Full-time non-manual staff numbered 12,990 compared with 12,760 in 1956–57, and at least 1,870 part-time paid staff were also employed. There are at least 32,755 public library service points in the United Kingdom, including 569 municipal central libraries and county headquarters, 1,333 full-time branches, and 30,853 part-time branches, centres, etc., as well as 200 mobile libraries.

Instrument Construction

THE Russian monthly *Priborostroenie*, which is described as a "scientific, technical and production" journal, is being produced in an English translation under the title *Instrument Construction* (No. 1, 1959. Translated from the Russian. Pp. 38. Published monthly. Subscription £6 yearly post free (17.10 dollars U.S.A. and Canada). Special rate of £3 yearly post paid (8.55 dollars U.S.A. and Canada) available to University and Technical College Libraries. Single copies 15s. each (2.15 dollars U.S.A. and Canada). London: Taylor and Francis, Ltd., 1959), by the British Scientific Instrument Research Association for the Department of Scientific and Industrial Research It covers industrial instruments and instrumentation, automatic control and production engineering for precision work and affords a valuable insight into current Russian practice in these fields The first number of the journal corresponds to the January 1959 issue of *Priborostroenie* and each issue of the English journal, because of the time needed for translating and printing, will be published two and three months later than the corresponding Russian number The contents of the first number includes five short articles from the twenty-first congress of the Communist Party of the Soviet Union The articles pay tribute to Mr Khruschev's report "Targets for the Development of National Economy of the USSR for the period 1959–65", and deal mainly with various aspects of the extension of automation in industry in furtherance of the seven-year plan The more technical articles deal with the automatic control of ferro-alloy furnaces , a transistorized analogue computer , an electronic phasemeter with a range of − 180° to 180° , and field magnets and magnetic lenses for cathode-ray tubes with cold cathodes Laboratory notes, and reviews and abstracts from the pages of the Czechoslovak journals, make up the remainder of the contents

French Journal of Science Teaching

The first edition of *l'Enseignement des Sciences* has made its appearance (1, No 1 , May–June 1959 Hermann Paris 1,200 francs per annum) , it is to be published five times a year The journal aims to cover a wide field of science instruction and to publish as much original research as possible for the "amelioration of scientific studies" The first edition consists of 48 pages with seven plates, bold line graphs and some amusing Lima line cartoons The main article, the "Known Limits of the Universe", covers eleven pages and is well illustrated Articles follow on the importance of science in education, a report on the improvements in teaching at the Nancy school of mines, and modern mathematics and their teaching An extensive review of Jean Perrin's "Éléments de la Physique" is included, also an interesting article on the philosophy of children which is based on Charles Rollin's "Traité des Études" (1726) in honour of his memory Inquiring articles also occur on perceptions of geometry, etc The journal concludes with numerous short reviews and a section of general correspondence

Atomic Energy in Australia

The contents of the December 1958 issue of *Atomic Energy* (2, No 1), the quarterly published by the Australian Atomic Energy Commission to keep industry and commerce informed of progress in the field of atomic energy, includes an article by J L Symonds describing procedures for the commissioning period of the reactor *Hifar* , a review of reports made to the Second International Conference on the Peaceful Uses of Atomic Energy in Geneva during September 1958 on nuclear power developments in the various countries , and an authoritative discussion of the power position in South Australia by S E Huddleston, assistant general manager of the Electricity Trust of South Australia He maintains, contrary to the statements of many writers, that South Australia is not in need in the immediate future of nuclear power, largely because of the determined and efficient use being made of the power resources which are at present available The only economic coalfield in the state is at Leigh Creek, some 350 miles north of Adelaide, and in 1958, 694 million kilowatt hours were produced from Leigh Creek coal by the Electricity Trust This will be stepped up when new plant becomes available and it is expected that Leigh Creek coal will be fully exploited by about 1965 The increase in demands for electricity indicates that it will be necessary for South Australia to introduce nuclear power in 1970 but a decision to build an atomic power station there may not be made for another five or six years The future of nuclear power in Australia will be governed by the relative cost of generation from nuclear and conventional sources , the relative capital investment involved , and the availability and reliability of nuclear and conventional fuel Mr Huddleston considers that South Australia will be the first of the States to need nuclear power and his careful review of the relevant factors as they affect South Australia may prove valuable in assessing the value of introducing nuclear power into other parts of Australia

The Australian Museum

The annual report of the Trustees of the Australian Museum for the year ending June 1958 (Pp 19 Sydney Government Printer, 1959) records with appreciative comment the receipt of increased financial support from the Government It also states that the clearance of temporary buildings has been carried out and that the site is now ready for the new wing which will form the continuation of the northern frontage of the Museum for which working drawings have been prepared A generous gift by Sir Edward Hallstrom will enable the lecture theatre to be re-modelled and brought up to date and thus make it of more use to the rapidly developing schools service Much field work has been carried out by members of the staff and it is interesting to note that the appointment of a public relations officer has resulted in good publicity in many media

Sierra de Tamaulipas, Mexico

Between 1945 and 1955 Dr MacNeish, now of the National Museum of Canada, led three expeditions to the state of Tamaulipas in north-east Mexico, and in a new publication (*Transactions of the American Philosophical Society* New Series, Vol 48, Part 6 Preliminary Archæological Investigations in the Sierra de Tamaulipas, Mexico By Richard S MacNeish Pp 210 Philadelphia American Philosophical Society, 1958 5 dollars) he gives the results of his work in the Sierra de Tamaulipas, a range of hills in the south of the State It was not a favourable region for the development of elaborate cultures, although it was occupied for most of the time when the high civilizations of ancient Mexico were flourishing farther south The importance of this study, which is considerable, lies in the evidence obtained from excavations in a dry cave for the cultivation of maize and squash on a small scale at the very early date of about 2500 B C , in a mainly gathering and hunting culture This is the earliest satisfactorily dated example so far known of cultivated maize, and a discussion of its botanical implications was published by P C Mangelsdorf, the author and W C Galinat in *Botanical Museum Leaflet*, Harvard University, 17 (5), 1956

African Botany

A Vegetation Map of Africa in colour, with accompanying explanatory notes by R. W. J. Keay, and with a French translation by A. Aubréville, has been published on behalf of l'Association pour l'Étude Taxonomique de la Flore d'Afrique Tropicale, with the assistance of Unesco (Oxford University Press (1959), price 15*s*. in the United Kingdom only). The vegetation concerned is that which occurs south of the Tropic of Cancer. The author explains that the aim of the map is to show the vegetation as it is to-day and not the presumed climax types. He points out that the boundaries between the zones are seldom precise on the ground although, in the interests of clarity, they are thus represented on the map. The name selected for any particular zone relates to the most widespread natural or semi-natural type of vegetation found within it. Other necessary clarifying observations are also indicated.

'Parsnip' Dermatitis

Under this title B. J. Youngman has given an interesting account of various blisters and rashes caused by certain umbelliferous species, in particular those of *Heracleum* and *Pastinaca* (*Kew Bulletin*, 3, 387; 1958). In one instance, boys who had been playing with the giant species *Heracleum mantegazzianum*, using the stout stems as swords and telescopes, developed such severe red rashes and, later, blisters, as to require hospital treatment. This species of 'cow parsnip', which may grow to a height of 12 ft. with hollow stems 4 in. in diameter, is a native of the Caucasus. Originally introduced into Britain as a garden plant, it has now become naturalized in waste places, along rivers, etc. The author also discusses the edible, acrid, and vesicant properties of other species of *Heracleum* and of *Pastinaca*, to which the domestic parsnip (*P. sativa*) belongs, and cites evidence of more or less severe dermatitis effects which have been traced to them. She also recalls that some of the Umbelliferæ have not merely acrid and scalding juices or ingredients but are virulently poisonous, for example hemlock. So far the toxic principles present in species of *Heracleum*, *Pastinaca* and other umbelliferous plants have not been isolated or identified.

The Mammals of Banff National Park, Alberta

In 1885, an area of 10 square miles around the newly discovered hot springs in the Bow Valley of the Alberta Rockies was designated as Rocky Mountain National Park. This was Canada's first national park. Since that date the park boundaries have been altered several times, and the name has been changed to Banff National Park. The present area of the park is 2,585 square miles. It stretches for 210 miles along the eastern flank of the Rocky Mountain from latitude 50° 45′ to 52° 45′ N. The western boundary is the continental divide. Six main mountain ranges, the axes of which lie north-west–south-east, are contained in the park. A survey of the mammals of the extensive area has been made by A. W. Banfield, who describes 17 species in the Cordilleran fauna, 11 in the Boreal fauna, 7 in the Prairie fauna, 1 species in the Tundra fauna, and 18 of uncertain affinities (Nat. Mus. Canada, Bull. 159, Biol. Ser., 57).

The Ophitron

The General Electric Co., Ltd., announces that a compact microwave-generator embodying a new focusing principle has been developed at its research laboratories. The valve is an electrostatically focused backward-wave oscillator which has been named the 'Ophitron', after the Greek *ophis*, a serpent, the word being suggested by the undulating path of the electron stream flowing along the structure. The most striking advantages of the new oscillator are its small size (6 in. long and ¾ in. diameter) and low weight (7 oz.), and in addition the 'Ophitron' system has been designed to be simple to construct and to operate. A single stamped-out periodic structure and two flat focusing plates form the propagating path for the radio-frequency wave, and set up the periodic electrostatic field which focuses the electron beam. The system has the fundamental advantage that the crests of the undulating electron beam are brought into the region of maximum radio-frequency field. This feature gives good coupling between beam and wave, and leads to greater bandwidth than is obtained with the equivalent magnetically focused backward-wave oscillator. The present 'Ophitron' tunes electronically over at least a 40 per cent band in the 10,000 Mc./s. region. A range of such valves is envisaged, covering most important centimetre wave-length bands. It is expected that the noise performance will be better than that of magnetically focused backward-wave oscillators due to the ion drainage from the electron beam inherent in the focusing method.

Non-Oxide Glasses

Arsenic trisulphide glass is well known as a useful material in the construction of optical parts transmitting in the infra-red. It suffers from a very low softening temperature compared with the normal type of oxide glass, and so far there is very little promise of harder glasses being prepared with sulphur or selenium as the anion. Some of these glasses are semiconductors of high resistivity, greater than 10^6 ohm/cm./cm.^{2} The Bell Telephone Laboratories have just announced an ingenious application of glasses in this family which puts to practical use the low-softening point, the property which is undesired in the other present uses. Glasses composed of varying proportions of sulphur or selenium with arsenic and thallium become very fluid at temperatures between 125° C. and 350° C. In this temperature-range the viscosities of the various glasses approximate to that of castor oil at room temperature. These materials have been found to be eminently suitable for coating small electronic devices by dipping into the castor oil-like liquid. At room temperature the materials are typically glass-like solids inert chemically to most reagents except concentrated alkalis. Several compositions are said to resist oxidation in air to above 250° C. Initial experiments in coating semiconductor devices have shown considerable promise.

Joseph P. Kennedy, Jr. Memorial Foundation

A gift of one million dollars has been made by the Joseph P. Kennedy, Jr. Memorial Foundation for the establishment of the Joseph P. Kennedy, Jr. Laboratories for research on mental retardation, at the Massachusetts General Hospital. One half of this generous gift will be spent on the construction of these Laboratories and the other half will serve as an endowment to provide continuing operating funds. This is the first of the endowed scientific researchships planned under the 1961 programme in observance of the 150th anniversary of the Massachusetts General Hospital.

Royal Society Research Appointments

Dr J S Gillespie, of the Department of Physiology, University of Glasgow, has been appointed the first Sophie Fricke Royal Society research fellow in the Rockefeller Institute, where he will work on intracellular recording from innervated smooth muscle This appointment is a new post which has been established by the Rockefeller Institute from funds left to the Institute by the late Miss Sophie D Fricke of New York City, who died on March 1, 1958 The trustees of the Rockefeller Institute have authorized use of the income from the fund for the triple purposes of fostering international understanding, training scientists of exceptional promise and supporting significant research It is the intention of the Rockefeller Institute to appoint four research fellows each year, from France, Denmark, Sweden and the United Kingdom, the selection being made by the French Academy of Sciences, the Royal Danish Academy of Sciences and Letters, the Swedish Royal Academy of Sciences and the Royal Society

A Locke research fellowship has been awarded to Dr B G Cragg, of the Department of Anatomy, University College, London, to work at University College, London, on the connexion and physiological functions of certain nuclei in the brain Stothert research fellowships have been awarded to Mr W D Butt, of the Department of Biological Chemistry, University of Aberdeen, to work at the Molteno Institute of Biology and Parasitology, University of Cambridge, on intracellular hæmoprotein compounds , to Mr R A Webster, of the Department of Pharmacology, University College, London, to work at University College, London, on the pharmacology of tetanus, and to Mr J A Hunt, of Peterhouse, Cambridge, to work on the chemical structure of proteins

Leopoldina Academy New Members

It is announced that the following, with others, have been elected members of the German Leopoldina Academy of Natural Sciences, Halle Mathematics Section, Profs Herbert C Grotzsch (Halle) and Hans Schubert (Halle) , Physics Section, Prof Otto Kratky (Graz) , Geophysics and Meteorology Section, Prof Erik Herbert Palmén (Helsinki) , Chemistry Section, Profs Gunther Rienacker (Berlin) and Wilhelm Treibs (Leipzig) , Botany Section, Profs James Bonner (Calif), William O James (London) and P Maheshwari (Delhi) , Zoology Section, Profs A W Iwanow (Leningrad), E N Pawlowsky (Leningrad) and Fritz Peus (Berlin) , and Geography Section, Profs Rudolf Kaubler (Halle) and Ernst Neef (Leipzig)

University News

London

Prof W R Niblett, director of the Institute of Education, University of Leeds, has been appointed dean of the University of London Institute of Education with the title of professor of education in the University

The following appointments to University readerships have been announced Dr D J Anderson (physiology in relation to dentistry), tenable at Guy's Hospital Medical School , Dr A Ashmore (experimental physics), tenable at Queen Mary College , Dr F Hobbiger (pharmacology), tenable at Middlesex Hospital Medical School , Dr M B Shapiro (psychology), tenable at the Institute of Psychiatry , J W Stewart (hæmatology), tenable at Middlesex Hospital Medical School , Dr D F Cheesman (biochemistry), in respect of his post at Bedford College , Dr A P Millman (mining geology), in respect of his post at the Imperial College of Science and Technology

Southampton

The University has conferred upon Prof P Ford, professor and dean of economics, who is retiring on September 30, the title of professor emeritus Prof Ford will formally open the newly completed building for the Faculty of Economics and the Ford Collection of Parliamentary Papers on October 14 Mr R G Woods, of the University Library, Cambridge, has been appointed deputy librarian The title of senior lecturer has been conferred upon Dr G W A Fowles (Chemistry), Dr J P Jones (Aeronautical Engineering) and Dr R A Pelham (Geography). The following lectureships are also announced: Dr A N Clements (physiology and biochemistry); Dr J Heading (applied mathematics) , Mr R W Page (mechanical engineering) , Dr J R Rydzewski (civil engineering) , Dr R G Scurlock (physics) , Dr E V Vernon (electronics)

Announcements

Mr J B Adams, at present director of the Proton-Synchrotron Group of the European Council for Nuclear Research near Geneva, has been appointed director of a new establishment to deal with controlled thermonuclear research The work in this field now being done at Harwell, and some of the work now being done at the Atomic Weapons Research Establishment, Aldermaston, will be moved to this new establishment when its site has been chosen

The Elmer A Sperry Award "for outstanding achievement in the field of transportation" will be presented in 1959 to the de Havilland Aircraft Co , Ltd , the creators of the world's first jet passenger transport, the British-built *Comet* Formal presentation of the award will take place in New York later this year at a joint meeting of the Institute of the Aeronautical Sciences and the Royal Aeronautical Society The award is sponsored by four engineering societies the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Society of Automotive Engineers and the Society of Naval Architects and Marine Engineers

An international symposium on Algology will be held at the Indian Agricultural Research Institute, Pusa, New Delhi, during December 7–12, under the joint sponsorship of the Indian Council of Agricultural Research and Unesco Main topics which will be discussed are nitrogen-fixing algae, edible algae and their mass culture Further information can be obtained from the Unesco South Asia Science Co-operation Office, 21 Curzon Road, New Delhi, India

Erratum With reference to the communication entitled "A New Method for working up Processing Mixtures containing Anhydrous Aluminium Chloride" (*Nature*, July 11, p 117), Dr T Széll states that a mistake was made in preparing the English translation col 2, line 1, for "20 ml" read "25 ml"

CRYSTAL PHYSICS

THE presentation of the frontier regions of modern physics to an audience with a variable appreciation of scientific and mathematical ideas is, inevitably, a difficult task. None the less, it is one which should not be shunned, unless we are inclined to assume the semantic barrier to be impassable between the pure scientist and the educated public. In the realm of crystal physics with its many facets, the choice of electron-states in crystals as a topic for a discussion by Section A (Physics) of the British Association at the recent meeting in York, did not minimize the difficulties of communication. However, in the first lecture of the session, I attempted to wean the audience from a 'billiard ball' conception of atomic particles and, with little more than de Broglie's hypothesis and the Bragg reflexion law to assist me, to carry them into the mysteries of the energy-band theory of solids. It was not too difficult to begin a discussion of the wave behaviour of electrons in the ordered periodic-field of a crystal lattice, but the going became somewhat harder when the unavoidable introduction of wave vector space occurred. However, the vagaries of the effective electron mass were a little better appreciated by adding the visual aid of a bubble in a spirit-level as an analogy of the positive hole. It was inevitable that such treatment by analogy involved a considerable loss of rigour, but to me it proved to be a valuable exercise in transmitting the important results of the wave mechanical theory of solids without recourse to the mathematical building-materials allowable to the postgraduate seminar room.

The niceties of the band theory for electrons in a perfect crystal were soon disturbed by the reversion to practical situations. The next phase of the lecture dealt with the various crystal imperfections, their effect on electron and hole behaviour and their importance in semiconductor electronics. Again, treating the matter non-rigorously in terms of simple electrostatic forces, brings the problem of donor- and acceptor-levels and types of lattice vacancies into a relatively familiar perspective, and in this instance introduced some of the ideas to be used in the following lecture given by Dr. V. Hesketh.

Many of the important foundations of both experimental and theoretical solid-state physics were laid by the pioneer work of Prof. R. W. Pohl and his research school in Gottingen using the simplest of crystals, the ionic alkali halides. For an audience raised by this stage of the proceedings into the 'thin but bracing air' of wave mechanics, the appearance in a place of honour among beautifully coloured single-crystals of a familiar packet of common table-salt provided a 'down to earth' relief. The theme of Dr. Hesketh's lecture was the alkali halide crystal as a model solid for investigation. Such a claim appears to have been justified by the subsequent discussion. Optical, electrical and other studies provide some of the most certain evidence on the nature of lattice vacancies, single or in aggregation, in solid-state physics to-day. An important feature of this talk was the link which it indicated between such electronic investigations and those concerned with mechanical properties and the role of dislocations in crystals. A connexion with another interest of Section A, magnetism, was in evidence in the paramagnetic-resonance studies of alkali halides. From the general discussion which followed the lecture there was a hint that a 'North eye' was being turned towards dislocations by those, like Prof. L. F. Bates, who follow the motion of magnetic domains. It was a pity that there was no opportunity to demonstrate other links which are rapidly being forged between different branches of solid-state physics and those under examination.

If one might, in conclusion, offer an overall impression of this session in the proceedings of Section A at the York meeting, it is that the conditions of limited time and contact of the meetings have a very stultifying effect on any attempt to make an effective contribution to the communication of new physical concepts to a wider audience of educated people. On this occasion, in spite of the central position occupied by wave-mechanical ideas in the session, it was not a mathematical but a time barrier which blocked the transmission of information. Perhaps this will be borne in mind by the Association in framing a new position for itself as a most important medium for translation as well as transmission of scientific information. From my own limited experience, there is no doubt that courses extended over the year, making use of the facilities offered by extra-mural departments of the universities and similar organizations for further education, would provide a means of digestion for the strong meat of modern physics. As a corollary, the lecturer must bend his rigour of thought to breaking point so that he may admit familiar, though inadequate, analogies as carriers across the semantic obstacles.

G. F. J. GARLICK

SCIENCE BY THE UPPER FORM

AN innovation of Section X (Assembly of Corresponding Societies) of the British Association, whereby a selected panel of young scientists of sixth-form status are able to present short papers on projects with which each has been connected, was continued for the fifth successive year at the York meeting of the Association. This year there were five speakers drawn from Yorkshire schools, each one representing a school team engaged on the acquisition of scientific knowledge in the field, under competent leadership.

Ampleforth College, York, led the way with a paper by M. L. M. Wright on "Physiography and Scenery of the Isle of Eigg", excellently illustrated by colour slides showing the rugged grandeur of an isolated area along the western Scottish coast of only some twelve square miles in extent. Life is hard for the humans living there, and precarious for plant and animal life, dictated by Nature over countless years. The object of the expedition was to study the influence of land formation and climatic conditions on the vegetation of the island, even to an investigation of soil-salt content, which was found to vary considerably at different levels, the highest percentage of salt being at 500 ft., with diminishing amounts down to sea-level. Members of the party collected some 250 species of plant life, but no new records were discovered. Further work in the area is to be undertaken.

In a joint effort, the two speakers who followed (A. N. P. Butland and P. A. Crossley, of St. Peter's School, York) dealt with "Some Scientific Aspects of the River Ouse", the former confining himself to the work of the analytical chemist in connexion with water supply, a work in which he had taken part. Methods adopted in order to detect any possible contamination were described, and the results obtained at various points were given, from which it was apparent that the purity of Ouse water is well safeguarded.

P. A. Crossley concerned himself with 'foaming' in rivers and canals, a natural phenomenon the reason for which was explained, but in these days very much accentuated by the growing use of detergents. The River Don was said to foam much more than the Ouse, the Trent slightly less. Excellent slides were shown to illustrate foaming along these rivers, with graphs to present results of investigations made. Each speaker presented an interesting picture of problems involved.

"The Sedges of Askham Bog" formed the subject of Shaun Firth's paper, excellently illustrated by colour slides. The area investigated is well known to naturalists and close to York. It carries a variety of sedges but, so far as the speaker knew, no systematic study of them had been carried out, interest having ranged only around the rarer species, such as the handsome *Carex appropinquata*. In consequence a group of boys from Bootham School, York, including the speaker, undertook to remedy the omission. The aim was to compile a full list of species and, if possible, "to account for the presence and performance" of the sedges. "We are aware," remarked the speaker, "we have come nowhere near an exhaustive treatment of the subject . . . what made our study of the sedges so enjoyable was the fact that new data came to light with practically every visit to the Bog, to upset our rashly formed theories and force us to observe further and think again." So this, it would seem, is but the introduction to a hitherto neglected subject.

The Bar Convent Grammar School, York, was well represented by Nancy G. Proctor, who, after only eighteen months residence in the City, has absorbed much of its history, having received an introduction by becoming an assistant to Mr. Wenham, history master of St. John's College, York, who is carrying out an excavation under the ægis of the two local archæological societies. Thus Miss Proctor has in a short time been able to increase her knowledge of Roman antiquities, and to add this to her main interest in the archæological field which embraces the works of prehistoric man, in particular the study of promontory forts. Her work in York, even of so short a period, enabled her to trace the City's growth from the time when there was only an "insignificant wooden fort founded on the site in 70 A.D.", and to describe graphically recent investigations which she and members of her school have undertaken.

Another well-known Yorkshire educational establishment supplied both speaker and illustrator for the final paper, "The Seasonal Rhythm and Behaviour of the Birds of Bempton Cliffs", the former in the person of Eileen Burton, and the latter Joanne Littlefair, pupils of the High School for Girls, Bridlington. A bird-watching group visited Bempton at weekly, or twice-weekly, intervals during the year, where along an eight hundred feet stretch of the highest cliff, members studied the seasonal variation of population and the behaviour of six species of nesting seabirds—kittiwake and herring gulls, gannet, guillemot, razorbill and fulmar petrel. The date of the arrival of each species was carefully noted, together with time of egg laying and hatching, and departure. A count made along 200 ft. of the cliff showed the kittiwake to be the commonest species present during May (915), followed by guillemot (543), razorbill (18), fulmar (15), gannet (13), and herring gull (5). Five gannet chicks were hatched and reared in 1959, and as a pair of this species nested on a new ledge there would appear to be hope for an extension of the nesting area, which is the solitary British mainland station, all others being found on islands. A study was made of bird display at various times, methods adopted during time of incubation, and of the feeding of young, which gave Miss Littlefair an opportunity of producing drawings of remarkable quality, which were used to illustrate the talk in wall-chart form.

The Countess of Albemarle, president of Section X, occupied the chair throughout the meeting and in her closing remarks complimented the sixth-formers on their powers of observation, method of presentation and keenness in the respective tasks undertaken, a tribute not only to the young people but to their teachers and leaders as well.

J. A. S. STENDALL

THE MUSEUMS ASSOCIATION

THE sixty-fifth annual conference of the Museums Association was held at Worthing during June 15–19. The proceedings opened with an informal reception in the entirely re-organized Museum and Art Gallery and members were particularly interested in the additional accommodation provided by a new gallery, laboratory, workshop and storage space.

The Conference continued on the following day with an official welcome from the Mayor, Councillor Horace W. Bradley. This meeting, as the others, was held in the spacious and attractive rooms of the Assembly Hall placed at the disposal of the Conference by the Corporation of Worthing.

Dr. W. E. Swinton, British Museum (Natural History), in his presidential address, after outlining the early struggles of the Association, emphasized the value of television and urged both museums and art galleries to use it extensively. It was, he said, the acceptable medium of to-day, 'easy, lazy but direct'. There was abundant evidence that already it had attracted people to visit museums and see the actual objects Dr Swinton emphasized the close relation between science and the arts and stated that whereas thirty years ago they were pleading for more science in museums, which were then chiefly artistic, in this scientific age there was some need for a reversal of the process

The main subject of the Conference was museums and finance, introduced by Lord Rosse, chairman of the Standing Commission on Museums and Art Galleries After recalling the increase of grants from the government which had recently taken place, he emphasized particularly the need for more staff in museums The present shortage of staff was both absolute, because there were not enough qualified people, and comparative, because museum rates of pay were not competitive with comparable professions He felt that museums should not depend too much on the Exchequer but that local authorities and others should do their share Dr Barnett Stross hoped that curators would use the increased grant of £15,000 made available through the Victoria and Albert Museum He felt that the chief needs of the museum movement were for staff of high status with adequate pay, a high standard of conservation and for more realistic purchase grants Sir Hamilton Kerr thought that two stages were necessary, an immediate first aid operation and secondly an expert committee to consider all the problems confronting museums in Britain Sir George Dyson outlined the help that the Carnegie United Kingdom Trust had given to museums over the past thirty years, and Sir Philip Hendy gave some striking facts of the magnitude of the loss suffered by the decay of private patronage since 1914 Sir John Hobhouse outlined the initial steps taken by the newly formed South-West Regional Council, and Mr E M Hutchinson, National Institute of Adult Education, was anxious that local authorities should use to the fullest extent the power to raise money that has already been vested in them

At the close of the discussion resolutions were passed endorsing the recommendations of the Standing Commission relating to tax reliefs on gifts and bequests which should be made applicable to all museums , urging the Standing Commission to form a joint committee with the Museums Association to advise on all professional matters and requesting the Joint Committee on Government Assistance to make a survey of existing conditions in museums and art galleries

In a discussion on the country house and the museum, Mr R Romilly Fedden, secretary of the Historic Buildings Committee of the National Trust, emphasized that the great country house with its contents formed a living organism, and stated that the trust had close relations for expert advice and so on with museums Lord Methuen suggested that the Government might take over some of the empty great houses not too far from London and use them for showing secondary pictures from the National Gallery He also advocated the co-operation of persons with specialized knowledge on local authority committees Mr Philip James, director of Waddesdon Manor, stated that the crux of the problem for using furnished country houses as museums was how to get as many people as possible round the house without destroying its atmosphere as a home

At the annual general meeting Dr W E Swinton was re-elected president, Mr G L Conran was elected secretary and Sir John Rothenstein, editor Mr Charles Carter (Aberdeen), Mr R R Clarke (Norwich), Dr D Dilwyn John (Cardiff) and Dr Mary Woodall (Birmingham) were the newly elected professional councillors and Sir Hamilton Kerr, the Institutional councillor The Earl of Rosse and Dr D B Harden were appointed as additional vice-presidents It was decided to hold the 1960 Conference at Stoke-on-Trent during July 4–9

The concluding day was devoted to field meetings to inspect the historic and archæological wealth of Sussex

THE INTERNATIONAL VETERINARY CONGRESS

THE sixteenth International Veterinary Congress, held in Madrid during May 21–27, was attended by nearly 2,000 members of the veterinary profession from all continents, including official delegates from fifty-two countries and more than one hundred from the United Kingdom The Congress, under the patronage of the members of the Spanish Government, enjoyed the hospitality of the University of Madrid The inaugural general assembly and plenary session meetings took place in the large hall of the new and magnificent building of the Faculty of Law The variety of the papers—about 400 in all—presented during the Congress was very great They were concerned with physiology, nutrition, pathology, public health aspects of animal diseases, food products and veterinary education A balanced review is not practicable here, but a few papers of greater general interest and a few more interesting papers presented by British delegations can be mentioned

As a result of the extensive public interest and concern there has been considerable research and investigation into contamination of the Earth's surface with radioactivity, and its subsequent effect on farm animals, as well as on man and human food of animal origin It has been found that an extremely heavy environmental contamination with fission products would be necessary to produce any significant damage as a result of external exposure of farm animals to β- or γ-rays The radiation exposure of farm animals from grazing in contaminated areas presents no significant hazard to the animals, except perhaps in localities very close to test sites Cows contaminated with radionuclides may become a potential hazard to man through milk, in which they are secreted in more significant quantities than in any other animal food product Papers on this problem were presented by American, German, Dutch and Swedish workers It was generally agreed that in order to be able to appraise continually the effects of fall-out from atomic-weapon tests, and of the discharge into air and water of waste from all plants where nuclear energy is produced and applied, it is necessary to make regular measurements of the radioactivity present in soil, water, air and food

A role of the veterinary profession which has not yet been fully exploited is that concerning public health, and particularly the problem of diseases which are transmissible from animals to man Nearly one hundred diseases are known to be so transmissible, and additional ones are still being found Some of these diseases are transmitted by direct contact of man with live animals, others are transmitted indirectly to people through the consumption of milk, eggs or meat Diseases transmitted from animals to man are defined as 'zoonoses' At present there are many international groups or agencies that are concerned with the control of the zoonotic diseases, but still closer collaboration is necessary between the medical and the veterinary professions in protecting man from zoonoses

One subject which has not before been discussed was that of blood groups of domestic animals In dogs, six distinct blood group factors are recognized

As is the case with newly born babies, it is possible for newly born foals and pigs to die from hæmolytic disease, which is a pathological condition resulting from the union of maternal antibodies with blood-group factors of the red cells of the fœtus

There were several interesting contributions from Great Britain Workers at the Research Institute for Animal Virus Diseases (Pirbright) reported new knowledge on living attenuated vaccines which gives hope of a method of combating foot-and-mouth disease in countries where it is widely spread Foot-and-mouth disease is one of the most serious viral diseases affecting cattle in nearly every country of the world

Workers of the Glasgow Veterinary School have reported successful trials with a vaccine produced against lung-worm infection, which causes great losses in cattle and sheep Immunological basic work concerning parasites was reported by workers from Cambridge They also demonstrated a correlation between immunity and chemotherapy From the Cambridge Veterinary School there also came an important paper classifying respiratory diseases in poultry

A paper on the international standardization of veterinary biological products was delivered by the director of the Veterinary Laboratory of the Ministry of Agriculture and Fisheries

At a charming ceremony during the Congress the president of the Royal College of Veterinary Surgeons presented honorary associateships, awards usually made during the Congress, to five eminent foreign veterinary scientists

The Spanish people were the most hospitable hosts and, in addition to the well-organized scientific site of the Congress, they had prepared a very full programme of evening receptions and other social functions that were greatly enjoyed and appreciated by the members of the Congress At the closing general session of the Congress an invitation conveyed by the German delegation to hold the seventeenth International Congress in Hanover, in order to celebrate there the centenary of the Congress which first started in Germany, was received with acclamation The first International Congress on animal diseases was held in Hamburg in 1863 It was initiated by an English veterinary surgeon, Prof John Gamgee The principal subjects of discussion during the first congress were rinderpest, also called cattle plague, contagious pleuropneumonia of cattle and sheep pox All these diseases ceased to exist in Britain many years ago

The veterinary profession combating many devastating diseases of animals plays an important part, not only in the improvement of the health of animals, but also the health of man M A Soltys

PLANT GROWTH REGULATION

THE fourth International Conference on Plant Growth Regulation was held at the Boyce Thompson Institute for Plant Research, Yonkers, New York, during August 10–14 The Conference was sponsored jointly by the Institute and by the New York Botanical Garden and the Brooklyn Botanic Garden The programme was co-ordinated with the ninth International Botanical Congress held in Montreal, Canada, during August 19–29

The Conference was attended by many invited participants from seventeen countries The United Kingdom was represented by sixteen participants The last conference was held at Wye College (England) in 1955, and before that conferences were held at the University of Wisconsin in 1949 and in Paris under the auspices of the League of Nations in 1937

The first day of the Conference was devoted to naturally occurring growth substances, the second to the gibberellins, the third to the synthetic auxins, and the fourth to other plant growth substances Chairmen of the various sessions included, Prof K V Thimann (Cambridge, Mass), Dr H Burstrom (Lund, Sweden), Dr P W Brian (Welwyn, England), Prof F Lona (Parma, Italy), Prof R L Wain (Wye, England), Dr J Henderson (Tuskegee, Alabama), Dr P E Pilet (Lausanne, Switzerland) and Dr J van Overbeek (Modesta, California) Major evening addresses were given by Dr William J Robbins, director emeritus of the New York Botanical Garden, on the "Expanding Concepts of Plant Growth Regulation", and by Dr James Bonner (California Institute of Technology) on the "Probable Future of 'Auxinology' "

In addition to the scheduled papers ample time was provided for discussion The papers presented and the discussion remarks will be published in book form by the Iowa State College Press in May 1960 Copies will be sent to each participant and will be available to others at nominal cost

Among the new advances reported at the Conference was the isolation of a new class of auxins from Maryland Mammoth tobacco by Dr D G Crosby (Union Carbide Chemicals, South Charleston, West Virginia) and Dr A J Vlitos (Caroni, Ltd , Trinidad, formerly at the Boyce Thompson Institute) About 10 mgm of active chemicals were obtained from a ton of tobacco leaves and growing tips One of the chemicals was identified as 1-docosanol and the other as a long-chain fatty acid not yet fully characterized Bruce Stowe (Harvard) also presented results showing the growth-promoting activity of long-chain aliphatic compounds

Prof T A Bennet-Clark (University of London) reported on the effect of gravity on the distribution of auxins The metabolism of indole auxins in plants was discussed by C H Fawcett, R L Wain and

F. R. Wightman of Wye College. The isolation of a new acid from coconut milk which gives about half the stimulation produced by whole milk was reported by L. H. Weinstein, L. G. Nickell and W. J. Tulecke (Boyce Thompson Institute and Chas. Pfizer).

New concepts on the relation between structure and auxin activity with special reference to the requirements for reactions with necessary binding sites were discussed in separate papers by Prof. K. V. Thimann and Dr. J. van Overbeek. Some physical chemical aspects of synthetic auxins with respect to their mode of action were presented by Prof. V. Freed (Oregon).

This was the first international conference in which the gibberellins were discussed. The Japanese scientists who carried out some of the early work with the gibberellins, T. Hayashi, J. Kato and Yusuke Sumiki, were on hand to present their most recent results. Dr. P. W. Brian (Imperial Chemical Industries, Welwyn), who was a pioneer in directing the attention of the Western world to the Japanese discoveries and who has been very active in this field, reported on new developments from his laboratory. Evidence showing the probable widespread occurrence of gibberellin-like substances in higher plants was presented by C. A. West (University of California).

A feature of the Conference was a memorial dinner to the late P. W. Zimmerman (Boyce Thompson Institute), who with his associate A. E. Hitchcock first tested 2,4-D for its effect on plant growth and development. Other chemicals first tested in his laboratory include indolebutyric acid and 1-naphthaleneacetic acid as well as a variety of substituted derivatives of benzoic acid and various substituted aryloxyacetic acids. P. W. Zimmerman was originally a member of the organizing committee for this Conference but became ill while on a business trip and died in August 1958 at the age of seventy-four.

Financial support for the Conference was given by the Rockefeller Foundation, the National Science Foundation, and fifteen industrial companies interested in agricultural chemicals. George L. McNew, managing director of the Boyce Thompson Institute, was chairman of the Organizing Committee for the Conference. A. J. Vlitos was secretary of the Organizing Committee and chairman of the Programme Committee.

LAWRENCE P. MILLER

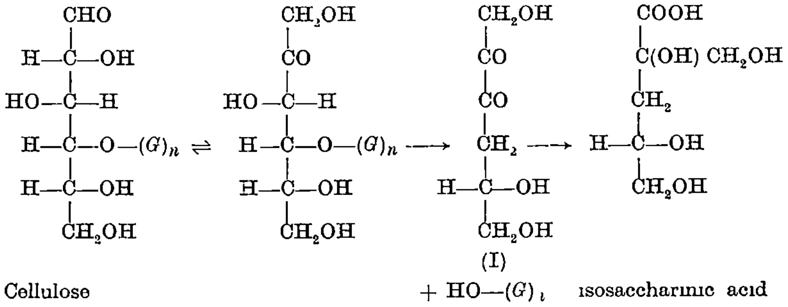
THE BRITISH RAYON RESEARCH ASSOCIATION

OPEN DAYS

THE British Rayon Research Association held the fourth of its annual open days during May 6–8. The total attendance was 900–1,000, a marked increase on the two previous years. Encouraged by the favourable reception last year, the senior chemist and senior physicist again gave short lectures, after lunch on each day, illustrating the relevance of the basic research to current problems in the textile industry. Instead of endeavouring to demonstrate all the work of the Association, a limited number of current researches on topical problems were illustrated rather more fully than usual, and it is believed that this approach may have been, in part at least, responsible for the very high attendance. Two aspects of the work, namely, that on fluid beds' and that on vibration problems in spinning machinery, were not exhibited because of the desire not to interrupt this work at a critical stage of evaluation.

During the past year the research programme of the Association has been critically reviewed particularly in view of the improvements required in the finishing of fabrics constructed from continuous filament viscose and acetate yarns to enable them to compete with resin-treated cotton fabrics. The emphasis on this work has led to a reduction in work on dyeing and on the photo-sensitized oxidation of cellulose and to the termination of the work on the alkaline degradation of cellulose. Concurrently with this, more attention is being given to research on the mechanical properties of textile fibres and to the study of the fine structure of crystalline polymers with the object of defining parameters which will characterize these polymers.

The recent work on the alkaline degradation of cellulose has considerably strengthened the conclusions on the mechanism put forward previously. This mechanism can be summarized in the following reaction sequence.



The intermediate (I) has now been isolated and its structure proved. The alkaline rearrangement of (I) is specifically catalysed by calcium and in lime water an almost theoretical yield of the isosaccharinic acid is obtained. The complex mixture of acids obtained with sodium hydroxide from this intermediate under the hot alkali-refining conditions used in purification of wood pulp is very similar, qualitatively and quantitatively, to that obtained from cellulose under the same conditions.

A considerable part of the resources of the Association are now directed to obtaining an understanding of the structure of textile fibres and attempting to correlate these with their physical, and particularly their mechanical, properties. On the chemical side a systematic study of the effect of known numbers of specific cross-links in cellulose and of substituents in specific regions, namely, crystalline or amorphous, of the cellulose on the mechanical properties has been in progress during the past year. The study of the formation of structure in solution-precipitated polymers is still in progress, but the first system examined, cellulose triacetate in chloroform, has been rejected. Polydecamethylene terephthalate in benzophenone appears to be a more suitable system. Further work on the fine structure of cellulose has established that the microfibrillar structures observed in 'Tenasco' and 'Fortisan' materials are not artefacts but are structural features of these materials. Their significance with regard to the physical properties of these materials has not, however, been established.

The determination of the amount of crystalline material in any crystalline polymer requires special consideration for each case. In the case of the determination of crystallinity in cellulose by X-ray methods the problem is to obtain the shape of the scattering of the amorphous component in which there is considerable orientation, as there is always considerable overlap with the crystalline reflexions. An independent assessment of the shape of the amorphous scattering curve is being made by comparing the information which can be extracted from the X-ray diagrams of highly oriented rayon fibres with the entirely 'amorphous scattering' of freeze-dried cellotetraose, and of ball-milled viscose and native cellulose fibres. (It is well established that ball milling will completely destroy the crystalline structure.) A study, by narrow-beam X-ray and other techniques, of the nature of spherulites in nylon and of their effect on the mechanical properties of this material has been started.

It is difficult to find a new approach to understanding the mechanical behaviour of textile fibres. A textile fibre is essentially a uniaxial solid and most measurements on stress/strain relations are referred to this axis. In many applications, for example the evaluation of the stress system in a yarn, the behaviour of the fibre in a direction perpendicular to this axis may be of equal importance. The mechanical behaviour of an elastic solid with axial symmetry should be completely characterized, within the region of small strains, by five constants. An attempt is being made to measure these constants on polymer films, which are more amenable to such measurements than fibres, and to study their dependence on orientation.

The main emphasis in the Technological Department has been, and will continue to be, on quality. In continuous filament yarns, periodic over-straining caused by inadequate control of tension in winding processes can cause a variety of faults in cloth which often appear markedly only after dyeing. Instruments have been developed for measuring processing tensions and the properties of filament yarns and these are now being marketed. This type of work has absorbed a large amount of technological effort. Certain weft-way types of cloth fault which occur as 'shiring' in continuous filament acetate fabrics and as 'cloudiness' in low construction nylon and 'Terylene' fabrics appear to be due to frictional effects between warp and weft yarns, and consequently, in the weaving research, more emphasis is being placed on these frictional effects.

The number of staff is 266. This total is made up as follows: research staff, 90; laboratory and technical assistants, 77; engineering, drawing office and maintenance staff, 59; library and administrative staff, 31; canteen staff, 9. L. A. WISEMAN

NEW RESEARCH AND PRODUCTION FACILITIES OF CIBA (A.R.L.), LIMITED

NEW research laboratories, a new production plant and sales office extensions of Ciba (A.R.L.), Limited, at Duxford, Cambridge, were formally opened by Dr. R. Kappeli of Ciba, Limited, on May 21 during the celebration of the twenty-fifth anniversary of the establishment of the Company.

The new laboratories are housed in an L-shaped, two-storied building of concrete and brick construction with large plate-glass windows giving the maximum internal illumination in conformity with modern concepts in laboratory construction. The new building, together with the existing research blocks, encloses three sides of lawn and shrub garden. Internally, the use of teak, exposed facing brick and white-painted surfaces accentuates the functional character of the design of the building.

The upper floor of the new building re-houses the research and development department, and the space thus vacated in the original buildings is being used for application and technical service work on wood adhesives. With the additional laboratory space now available in the upper floor of the new block, the group of graduate chemists and their technical assistants in the research and development department are able to explore more thoroughly the current resins marketed by the Company, resins of the epoxy-resorcinol, phenol, urea and melamine types. The work is concerned with the development of resins and hardeners for casting and laminating purposes, for chip-board and wood-glue manufacture, as well as with specialized applications such as adhesives for metal bonding, printed circuits, high-temperature performance and a host of other uses. The extreme variety of the applications to which these classes of resins may be put, and the differing conditions under which they are employed, necessitate a continued and intense search for modified and improved chemical properties and physical forms. An integral part of the investigations undertaken by this unit is the testing of these new and modified materials, and the upper floor of the new building contains a test room well equipped with the necessary machines. This department maintains a close co-ordination with the other departments in the organization concerned with the application of existing products. There is, in addition, a lecture room where frequent colloquia and lectures are given by scientists from the plastics and related industries and by scientists from the academic world.

The ground floor of the new building contains the laboratories of the newly formed fundamental research department, which is devoted to the study of the synthesis of new plastic substances with improved mechanical and electrical properties and with high-temperature and chemical stability. The scope of the work is not restricted to adhesives, but embraces the

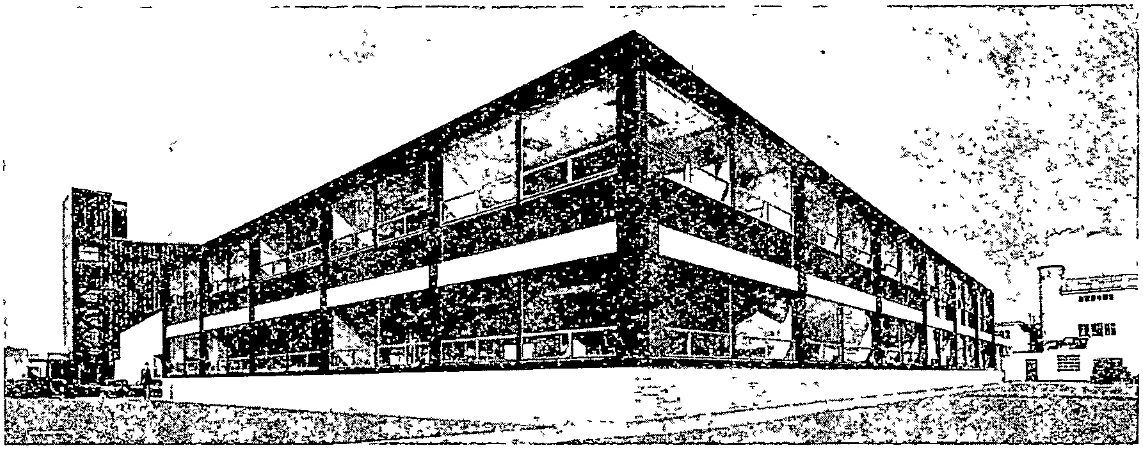


Fig 1 The new Ciba (A R L) research laboratories

possible uses of plastics in many fields The new group is divided into seven teams, each of which is investigating some distinct aspect of the problem, including the synthesis of new raw materials and the pursuit of new condensation and polymerization processes In addition to the usual equipment required for this type of work, the department has an analytical section where particular emphasis is given to infra-red and ultra-violet spectrophotometric and vapour-phase chromatographic analysis The ground floor also contains a central chemical and glassware store and a glass-blowing room, and there is easy access to the library, which has also been expanded to meet the increased requirements

The addition to the research staff at Duxford brings the proportion of those employed in laboratories on research, application, formulation and quality control to twenty per cent of the total staff employed It is clear that the laboratory work can be greatly assisted by the use of modern and automatic equipment and wherever possible this is done, but the quality and quantity of these investigations are still dependent upon the individual skill, knowledge and efforts of the scientist and technician, and every new field entered necessitates an increase in the laboratory staff In contrast to this, the factory has repeatedly been able to increase the volume of production without proportional increases in the labour force employed, and this has been possible only by the continuous introduction of fully automatic processes An outstanding example of this is provided by the new plant, which is now in production, for the manufacture of epoxy resins—resins based upon the condensation of diphenylol propane with epichlorhydrin This plant—although it has a working area of more than 16,000 square feet, several types of reaction vessel and ancillary distillation units with miles of pipe work and more than 500 valves—is maintained by only three men per shift and has more than five times the capacity of the plant it replaces In the new plant the equipment has been designed with the view of minimizing fire hazards, the building itself is of concrete and glass with dished floors to contain spillages, is well ventilated and sited away from the tank farm for the inflammable solvents used in the process, and also from the accompanying control laboratory and switch-house

These new facilities, continuing the programme of expansion of both research and production, demonstrate the rapid growth of the industry and the faith of those who have determined this growth from the modest beginnings of the early 1930's R F WEBB

THE ATOMIC ENERGY AUTHORITY

REPORT FOR 1958–59

THE fifth annual report (pp vii+68+4 plates London H M Stationery Office, 1959 5*s* net) of the Atomic Energy Authority and the last to be issued over Sir Edwin Plowden's signature, who is being succeeded as chairman by Sir Roger Makins on January 1, 1960, covers the year ended March 31, 1959 In that year work started on construction at Windscale of the advanced gas-cooled reactor prototype, the last of the four Calder Hall reactors became critical on December 8, 1958, the first reactor at Chapelcross came into use for generating electricity on February 25, 1959, and the Authority's staff increased from 30,341 to 35,260 No final decision has been reached regarding the transfer from Harwell to Winfrith Heath of the whole of controlled thermonuclear project The terms of the first contract for the supply of fuel for a nuclear power station overseas —the Latina station of Agip Nucleare—were negotiated during the year The Industrial Group has been divided into two groups development and engineering, under Sir William Cook, and production, under Sir Leonard Owen, executive, as well as functional, responsibility has now been restored to the technical members of the Board

The report reviews briefly progress made during the past five years in the application of nuclear energy, during which the first five large-scale nuclear power stations came into operation besides Calder Hall and Chapelcross, the United States 60 MW pressurized water reactor power station at Shippingport, the French 30 MW gas-cooled, graphite-moderated reactor power station at Marcoule and the U S S R

100 MW. graphite-moderated, water-cooled reactor power station in Siberia. In the United Kingdom gas-cooled, graphite-moderated reactors developing towards exit gas temperatures of 550° C. and 750° C. promise to lead to higher efficiency and ratings and a 30 per cent fall in capital costs of nuclear power stations is predicted with the development of the present main types. The application of radioactive isotopes continues to grow, including the use in industry of control instruments based on radioactive isotopes, such as thickness gauges. Total sales of radioisotopes and related products rose from £650,000 to £800,000, the proportion exported remaining at about 60 per cent, to 55 countries. Plans for the extraction of radiocæsium from radioactive waste are being considered in the United Kingdom and the potential output amounts to tens of millions of curies per annum. In raw materials, developments during the year confirmed that the present over-supply of uranium is likely to persist at least until the late 1960's, and the uranium requirements of the free world's current military and civil programmes can now be met by mines already in production, and it seems likely that the forward price of uranium may fall below 8 dollars per pound.

Apart from its first aim of ensuring the successful construction and operation of the nuclear power stations now under construction for the electricity boards, the Authority's reactor development programme comprises extensive work on the development of more advanced types of reactor, the aim of which is to provide progressively cheaper sources of nuclear power, and here the achievement of lower capital costs is a major objective. Efforts are being made to develop ways of using as fuel the plutonium that will gradually become available from the burning of uranium in the early stations. Beyond the natural uranium reactors two stages of development are envisaged. First, the advanced gas-cooled reactor and the water-modulated reactors seek to attain lower capital costs by using slightly enriched fuel. Secondly, the high-temperature gas-cooled reactor being developed at Winfrith Heath as a joint project with other member countries of the European Nuclear Energy Agency, and the fast breeder reactor at Dounreay are characterized by both low capital costs and negligible net fissile fuel consumption. While the present type of gas-cooled, graphite-moderated reactor may command a market overseas where large stations are required, the report points out that considerable advances in nuclear technology will be required before smaller reactors (20–100 MW.) become competitive in normal circumstances. The study of plutonium utilization in reactors continued as well as reactor physics studies in several zero energy reactors.

The report summarizes further research on controlled thermonuclear reactions. The main object of the present experimental programme on *Zeta* and *Sceptre* III is to discover the reason for the excessive loss of energy to the torus walls during the current failure. Work on smaller-scale gas-discharge devices was considerably expanded and some of the formidable technological problems involved in building a thermonuclear reactor are being studied. An Advisory Committee under the chairmanship of the Board Member for Scientific Research was set up in December 1958 to examine and keep under review all aspects of the Authority's research programme on controlled thermonuclear reactions, to advise the Member responsible for research policy on the merits of proposals for new work, and to make recommendations on changes in policy which seem necessary. Other research and development work being carried out by the Research Group, the Industrial Group and the Weapons Group is also briefly summarized. The first ranges from metallurgy, the physics of the solid state to work on particle accelerators. That of the Industrial Group extends far beyond the Group's laboratories, and extra-mural agreements between the Group and universities, research associations and industry now accounts for about a tenth of the Group's annual expenditure on research and development. That of the Weapons Group is illustrated by its examination of soluble chelate complexes of the alkaline earth metal ions and by its measurements of particle size, including use of a centrifugal system to increase the rate of sedimentation with the photo-sedimentometer.

Since its establishment in 1958 under the chairmanship of Sir Douglas Veale, the committee advising the Authority on the supply of specialized health and safety staff has had detailed consultations with many Government departments, hospitals, universities and industry. An interim report to the Authority recommended the initiation of courses in radiobiology and radiological physics at selected universities and provision of studentships if possible for the 1959–60 academic year. This recommendation has been accepted in principle by the Authority and details of the scheme are being worked out in collaboration with the University Grants Committee and the Department of Scientific and Industrial Research. The amount of research and development work contracted out by the Authority continues to increase and more than three hundred professional staff and technical staff from industry have worked with Authority staff during the year.

THE INSTITUTE OF PHYSICS

THE main sections of the thirty-ninth annual report of the Board of the Institute of Physics for 1958 (Pp. 18. London: Institute of Physics, 1959), which was presented to the annual general meeting of the Institute on July 7, deal with membership, examinations, education and publications. During the year, 851 applications for election or transfer to the various grades of membership were received. The total membership increased by 415 to 6,309, with a slight decrease in the number of subscribers (430 compared with 453 in 1957), but with fairly large increases in the associateship and student membership grades. Seven technical colleges which had applied for recognition as institutions possessing courses of study approved for the purpose of the membership regulations were visited by representatives of the membership and examinations committee and six of the applications were approved. In addition, the application by the Borough Polytechnic, London, for recognition of courses on which the Diploma of Technology in physics is awarded was granted. Twenty-six of the eighty candidates who presented themselves for the examination for the graduateship grade of membership were successful , twelve were university graduates and fourteen held the Higher National Certificate in applied physics Forty-one colleges presented 637 candidates for the Ordinary National Certificate in applied physics and twenty colleges 246 candidates for the Higher National Certificate

A joint committee of the Institute and the Physical Society has been set up to inquire into the postgraduate training of physicists and has held discussions with university and industrial physicists The report on "The Teaching of Mathematics to Physicists", which was prepared by a joint committee of the Institute and the Mathematical Association and published originally in 1943, is now being revised The Institute was invited to give its views on the subject of grants to students, and the text of the memorandum submitted by the Board to the governmental committee under the chairmanship of Sir Colin Anderson was published in the January issue of the Institute's *Bulletin*

Satisfaction is expressed in the annual report at the standard and increased circulation of the Institute's older monthly, the *Journal of Scientific Instruments* There was no significant change in the circulation of the other monthly, the *British Journal of Applied Physics*, but both journals suffered a further decline in advertisement revenue New arrangements for selling advertising space to become effective during 1959 and for widening the scope and content of the *British Journal of Applied Physics* have been decided upon A new feature in the 1958 *British Journal of Applied Physics* was the introduction, in the June and October issues, of a 'New Books' section which together contained reviews of 87 books The type size of the *Bulletin* was reduced for the 1958 volume This resulted in a considerable saving in paper, but the 366 text pages, comprising twenty-five articles and fifty-two book reviews, etc , contained more material than the 404 pages of the previous volume

The first annual dinner of the Institute was held on March 26, 1958, at the Savoy Hotel, London, when 267 members and guests were present

The Institute maintains nine branches and seven specialist groups in Great Britain, and two branches overseas, in Australia and Malaya respectively The activities of these sections are briefly described in the annual report, together with extracts from the reports of the Board's representatives and nominees on joint and other committees and organizations The South Australian Division held the sixth Australian instrument exhibition in Adelaide during August 19–22, at the same time as the Adelaide meeting of the Australia and New Zealand Association for the Advancement of Science The second Einstein Memorial Lecture was delivered in October in Adelaide by Prof B J Bok, who took as his subject "Stellar Evolution" The London and Home Counties Branch held a joint meeting in March with the London Section of the Royal Institute of Chemistry on the subject of science and society, and the South-Western Branch joined with the Education Group in a three-day conference in April at the University of Bristol on "Physics in Schools" The Electronics Group and the Midland Branch collaborated in a one-day symposium during April on some applications of solid-state physics in computers and automation, and in September the Group held a two-day conference on "Solid-State Memory and Switching Devices" at University College, London The Non-Destructive Testing Group held its summer meeting in Paris jointly with the Société Française de Métallurgie, when the subject of discussion was "The Utilization of Physical Properties for Studying Relationships between the Constitution Structure and Service Behaviour of Metals"

At the general meeting of the Institute, the following were elected to take office on October 1 *President*, Sir George Thomson , *Vice-President*, Dr J M A Lenihan , *Hon Treasurer*, Dr J Taylor , *Hon Secretary*, Prof F A Vick , and *New Ordinary Members of Council*, Dr V E Cosslett and Mr L Rotherham.

SOME INTERNATIONAL GEOPHYSICAL YEAR ACHIEVEMENTS

THE Royal Society has issued under the above title a small pamphlet constituting an interim statement at the end of the observational phase of the International Geophysical Year The pamphlet contains short notes, arranged under the fifteen subject fields, of statistical details of the work done and of important new deductions so far made from the International Geophysical Year observations Some features of special interest are as follows

Meteorology Ozone observations at the Royal Society base, Halley Bay, Antarctica, show an annual variation in total ozone content with a sharp increase in early summer markedly different from the variation over the Arctic where there are smooth rises and falls about an autumn minimum

Geomagnetism Halley Bay is found to have been most advantageously sited for recording geomagnetic disturbances as it is the only antarctic station just outside the zone of greatest concentration of ionospheric currents In one magnetic storm the range of the fluctuations in horizontal force reached the enormous value of one-sixth the average value of horizontal force

Ionosphere Halley Bay has recorded remarkable features in the diurnal variation of ionospheric electron density in winter The noon value in winter exceeds that at noon in summer and is ten times that at midnight In summer the diurnal range is small with a minimum at midnight These variation types change over suddenly near the equinoxes

Solar activity United States ionospheric observations made by rocket reveal the existence of a powerful flux of solar X-rays at the time of a solar flare This X-ray flux produces the increase in *D*-level ionization which in turn affects long-range radio communications

Cosmic radiation Cosmic ray measurements made by Van Allen with the United States artificial satellites have, as is now well known, revealed the existence of an intense belt of cosmic radiation surrounding the Earth

Oceanography British ships have observed directly the deep ocean currents of the North Atlantic using the 'Swallow' acoustic signalling float which can be set to drift at the required depth One of the currents measured was a southward one below the Gulf Stream

Nuclear radiation The existence of the International Geophysical Year network of nuclear sampling stations in Europe permitted a detailed study to be made of the diffusion of radioactive material released by the Windscale nuclear reactor accident in November 1957

The full prescribed observational work ceased with 1958 and the main task of the present and future is the study of the observations made during the year It is, however planned to continue some observations, apart from those which are part of regular meteorological, etc , services, during 1959 under the title "International Geophysical Co-operation 1959"

The International Council of Scientific Unions has formed special committees to co-ordinate further international work in antarctic research, oceanic research and space research

A further possibility is the making of a magnetic survey on a world-wide scale during the next sunspot minimum for comparison with the magnetic observations made during the maximum period with which the International Geophysical Year was timed to coincide.

RADIO FIELD-STRENGTHS IN THE TROPICS

It is well known that radio-communications conducted by waves which are propagated by reflexion from the ionosphere are critically dependent on the properties of the layers of ionized gas which transmit and attenuate the signals The regular observation of the characteristics of the ionosphere at stations distributed widely over the Earth's surface has made it possible to understand and explain many phenomena which were obscure even ten years ago The International Radio Consultative Committee has, among its other studies, been investigating many technical problems involving the propagation of radio-waves by way of the ionosphere , and of these a most important one is that of tropical broadcasting, for which high-frequency waves are much more effective than medium waves on account of the very high atmospheric noise-level present in most tropical regions Unfortunately the attenuation of the signals in the higher-frequency bands is much greater during the day than is usual at higher latitudes and the reflecting layers are also less stable Thus the problem of providing an adequate signal-to-noise ratio is considerably more difficult in the tropics

The past studies of the International Radio Consultative Committee had shown that the standard methods of computing the field-strength of sky-wave signals were considerably in error at low latitudes , but it also became clear that the additional basic data obtained in recent years provided an explanation of many of the discrepancies disclosed In a report* by W R Piggott, recently published by the Department of Scientific and Industrial Research, Radio Research Station, this subject is reviewed with the aid of an analysis of the problem of identifying the most effective type of ionospheric reflexion for particular circumstances This report shows that some of the difficulties in interpreting the results of field-strength measurements at low latitudes have been due to changes in the dominant mode of ionospheric propagation, and the consequent variations in the attenuation of the waves, and the angle of elevation at which they arrive at the receiver The rate of advance of knowledge of this subject depends on the continual interplay of practical observations with theory , and it is hoped that the publication of this report, together with its presentation at the Plenary Assembly of the International Radio Consultative Committee recently held in Los Angeles, will encourage radio research workers in low latitudes to investigate their wave-propagation phenomena in more detail

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* Department of Scientific and Industrial Research Radio Research Special Report No 27 , The Calculation of the Median Sky Wave Field Strength in Tropical Regions By W R Piggott Pp 38 (London H M Stationery Office, 1959) 2*s* 6*d* net

BRITISH BOOKS AND FOREIGN MARKETS

In reply to a series of questions in the House of Commons on June 22 regarding the supply of British books and periodicals overseas, Dr C Hill, the Chancellor of the Duchy of Lancaster, made a long statement which was circulated in Hansard The study of ways and means of increasing the flow of British books and periodicals overseas has now been completed Recognizing that British books can do much to help other peoples to understand our way of life and that they make a very real contribution to the life and thought of other nations, the statement points out that there is an ever-increasing demand for reading-matter in English, and we must do more to promote the flow of British reading-matter overseas Other countries are already producing large amounts of well-produced attractive literature which is easy to read and inexpensive and is aimed particularly at Asian and African countries Although in 1958 exports totalled nearly £24 million, or almost two-fifths of the turnover of the United Kingdom book trade, several countries impose, for currency reasons, substantial restrictions on imports of British books and periodicals and our exporters cannot make further headway in these markets Low individual incomes in many countries and the lack of effective library and other distribution systems are also major difficulties

Accordingly, the Government has decided to take five steps to promote the export of British books and periodicals

(1) To enter into negotiations with various countries with the aim of establishing schemes operating

broadly on the lines of the British book export schemes which were established during the War and in the immediate post-War period

(ii) To promote the production of low-priced editions of a range of British books for sale in certain countries where there is a large unsatisfied demand for such books This will call for substantial Government expenditure

(iii) To authorize a further expansion of the British Council's library services in several centres and of the Council's resources for presentations of books and periodicals abroad on which the Council this year expects to spend in all about £650,000

(iv) To assist, through the British Council, in the development of library systems in some Colonial territories, including the establishment of central libraries, regional branches, book vans and book boxes

(v) To co-operate with publishers in measures to enable them to increase their circulations in some of the more difficult markets overseas

Parliamentary approval for the expenditure involved will be sought at the earliest convenient opportunity and it will be necessary to proceed in consultation with the Governments of the Commonwealth and foreign countries concerned, and Dr Hill promised to inform Parliament as soon as agreements had been concluded In reply to a further question Dr Hill said that the increase in the British Council's resources would be concentrated on scientific and technical books, but the schemes to be negotiated with countries where import restrictions prevent the flow would cover a wide range of books He hoped that in the next year it would be possible to reach up to 2 million copies of low-priced books This would be done in association with the publishers who own the copyright of the books concerned and would involve Government aid to narrow the gap between the economic price and what could be paid in the countries of reception Replying to specific questions, Dr Hill said that British book exports in 1958 to India were recorded in the Trade and Navigation Accounts as £424,427, to Pakistan £39,950, to Ceylon £15,732 and to Israel £9,473 Dr Hill estimated the increased expenditure as about £500,000 next year.

FORESTRY IN NEW ZEALAND

THE annual report of the director of forestry of New Zealand for the year ending March 31, 1958, is of more than usual interest in that it includes a general historical review of both departmental activities and general land use and administration, covering the past forty years The need for such a review had been particularly stressed by the Minister of Forests (Mr Tirikatene) and was prompted also by the meeting of the British Commonwealth Forestry Conference which had been held in the country during September–October 1957 The Minister himself (a Maori) contributes a prologue recognizing that the great forestry effort involved in creating a very large acreage of exotic softwood plantations, mainly of *Pinus radiata* from California, by the quick production of an alternative supply of essential timber, has saved a large remnant of the native forest at the same time he calls for much greater attention to the maintenance of this forest, especially for its value in protecting soil and conserving water The disastrous consequences of the denudation of the hillsides in the form of soil erosion and then extensive floods are all too widespread and serious to be ignored any longer Quoting two specific examples, he suggests that the Urewera indigenous forests in North Island, largely in Maori ownership, might in the national interest have to be managed primarily for soil stabilization and water retention, not timber, while in the hills behind Canterbury, all land more than 3,000 ft high might have to be taken out of pastoral use, even the city itself is now threatened by flood devastation It must be encouraging to the Forest Service to have this official backing, which is combined with full recognition of the essential need of stable finance for the necessary research work and for remedial measures

The visit of the Commonwealth Conference stimulated the preparation of a number of research papers covering many of the lines of activity which have called for special attention of recent years Some of the topics dealt with are also currently prominent elsewhere, especially where softwood plantations play an important part, such are problems in genetics, and the relation between sylvicultural treatment and market requirements in respect of both dimensions and quality (whether for timber or pulp) There are also problems of the later management and regeneration of the plantations, as in the United Kingdom During recent years, a good deal of thought has been given to the management and regeneration of the native forests, both those with important softwoods, notably kauri (*Agathis australis*) and the various species of *Podocarpus*, and the 'beech' forests (*Nothofagus* spp) Encouraging progress is being made but rates of development are, of course, very slow compared with those of the introduced conifers, and, as already noted, these forests have other functions to fill as well as timber production

The Commonwealth Conference appointed a special committee to report on New Zealand forestry In the report, as Resolution 6 of the Conference, alarm is expressed at the poor condition of the remaining indigenous forest as a result of past exploitation, and expansion of research programmes is urged, the publication of Volume 1 of the "National Forest Survey of New Zealand" for these forests in 1953 is commended, as is also the extension of the survey to protection forests

It may be noted that damage to the native forests by introduced animals, above all red deer and opossums but also wild goats and pigs, is still a really serious problem, so much so that there is a special division to deal with 'noxious animals' To reinforce shooting operations in the natural forests, bounties are paid for animals killed outside The numbers killed in the year in what do not claim to be more than 'holding' operations are striking, namely, 55,000 deer, 28,000 goats, 4,000 pigs and 4,000 chamois by the State alone The opossums are mostly killed outside the reserves, 900,000 in the year (after more than a million in 1956)

The control of noxious animals was only taken over by the Forest Service two years ago and there is a strong case for a similar taking over of soil conservation and river control, so that the troubles can be dealt with at their source instead of trying to remedy them after the damage has already been done, as is currently happening

There is still a big exotic planting programme, 8,744 acres having been added in the past year. The major features are the clearing and replanting of former failures, notably those with *Pinus scopulorum*, a mistaken choice, and the extension of the work on to the coastal sands of the North Island which are unsuitable for agriculture, where the plantations will not only be productive in themselves but will also protect the fields from sand encroachment.

The annual report of the New Zealand Forest Research Institute for the same year ending March 31 (Pp. 100. Wellington: Government Printers, 1958) amplifies many of the points referred to above, and it also looks back over its first decade of work, expressing the feeling that it is now well established as a fully co-ordinated research centre, with an advisory committee representing both industry and all related research organizations. The graduate staff now numbers nearly fifty with a comparable number of technicians, but the Commonwealth Conference thought that there is still need for an increase on both the forestry and forest products sides.

H. G. CHAMPION

UBIQUINONE AND VITAMIN E

By DR. THOMAS MOORE

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SOME time ago we noticed[1] the presence in the livers of rats of an alkali-labile substance with a sharp absorption band at 275 mμ. For the purpose of studying the distribution of vitamin E in the body the rats had been given diets which were only barely sufficient in vitamin A. This restriction was intended to eliminate the strong spectroscopic absorption of vitamin A at 328 mμ, and so allow the measurement of vitamin E by its weaker absorption[2] at 294 μm. In the body-fat of rats given wheat germ, rich in vitamin E, the presence of this vitamin was readily detected. In the liver, however, the detection of vitamin E was made difficult by the absorption at 275 mμ which has already been mentioned.

We were reminded[3] of these early observations by reports by Lowe, Morton and Harrison[4] of fractions from the livers of rats deficient in vitamin A which adsorbed at 275 mμ, with other maxima at 233, 283 and 332 mμ. These workers thought, at the time, that abnormal steroid products had been formed as the result of the avitaminosis. We confirmed the presence of a band near 275 mμ in liver extracts of rats deficient in vitamin A. Saponification of the liver-fat with hot alcoholic potash caused the band to disappear, but it survived the same treatment when applied to the liver tissues. Presumably the tissues protected an unstable substance against oxidation. The band disappeared from solutions which were treated with 85 per cent sulphuric acid, were aerated, or stored for 37 days at − 10° C.; it survived treatment with digitonin. Sterol-free extracts of unsaponifiable matter, made by the direct saponification of the tissues, were neither fluorescent under ultra-violet irradiation nor chromogenic in the antimony trichloride test. By paper chromatography evidence was obtained of the presence of two substances with absorption maxima at 275 mμ. One had a single sharp band at this position, but the other had also an inflexion at 330 mμ. Both substances were faintly yellow, but had no selective absorption in the visible. Bands at 272–275 mμ were also found in liver extracts from rats which had been cured of avitaminosis A, from normal sexually immature rats, and from a normal pig and guinea pig.

The existence of two substances, with their main absorption maxima at the positions observed by us[3], was also reported by Heaton, Lowe and Morton[5]. The names substance *A* and substance *C* were given. Both had their absorption maxima at 275 mμ, but *C* differed from *A* in having a sharper inflexion at 330 mμ; both substances *A* and *C* were found in the livers of normal animals, although the concentration of substance *C* in the liver of normal rats was much lower than in the livers of rats suffering from vitamin A deficiency. *A* and *C* were also found in various tissues other than liver, and in different species[5,6].

Further extensive investigations by the Liverpool school, reviewed by Morton[7], have led to the isolation of substance *A*. It is not a sterol product, as first expected, but a derivative of 1-methyl-5,6,dimethoxy *p*-benzoquinone. In view of its wide distribution the name ubiquinone was given. The striking feature of its structure is a long unsaturated side-chain, comprising 50 carbon atoms, attached at the 2 position. Similar conclusions as to the constitution of ubiquinone, otherwise known as *Q* 275 [8] or mitoquinone[9], have been reached in America[10]. According to Lester, Crane and Hatefi[11], ubiquinone is only one of a whole new series of quinones, which vary in the nature of the side-chain.

Some workers[12] consider that ubiquinone plays an important part in tissue oxidations. Others[13] have ascribed a similar role to vitamin E. The roles of both vitamin E and ubiquinone in heart muscle preparations have been reviewed by Slater[14], who has suggested that the question whether there is a chemical or functional relationship between the two substances deserves investigation.

Vitamin E and ubiquinone have common properties in being soluble in fats, in being capable of undergoing reversible oxidation or reduction, and in being unstable to alkaline saponification in the presence of oxygen. They differ in vitamin E being found in animal tissues mainly in the reduced state, whereas ubiquinone is mainly in the oxidized state. Regarding their distribution, ubiquinone has been found mainly in mitochondria, whereas vitamin E can be stored in the body-fat[1]. Since vitamin E is a potent anti-oxidant, it might possibly intervene in the metabolism of ubiquinone by protecting it against irreversible and destructive oxidation.

It was of interest, therefore, to inquire into the effect of vitamin E deficiency on the concentration of ubiquinone in the tissues. The preliminary evidence on this point[1] may now be re-examined on the basis of pure ubiquinone having E (1 per cent, 1 cm.)[15] at 272 mμ = 167. A rough estimate of the concentration of ubiquinone, without allowance for the possible presence of substantial amounts of substance *C*, may be calculated from the difference

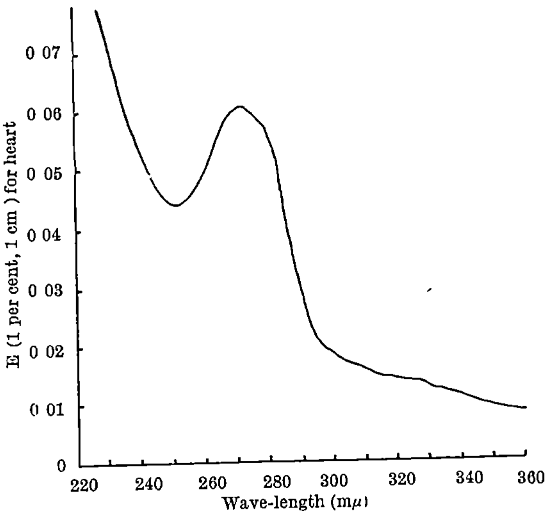

Fig 1 Absorption spectrum of an extract of the heart of a rat, deficient in vitamin E The presence of ubiquinone is indicated by the maximum at 275 mμ

between the absorption of the extracts at 275 mμ before and after saponification On this basis the liver of a rat which had been kept for four months on a diet deficient in vitamin E contained about 320 μgm of ubiquinone per gm The liver of a rat which had been kept for two or four months on a diet containing 60 per cent of wheat germ, and therefore rich in vitamin E, showed little difference from that of the deficient animal with 270 and 290 μgm per gm of ubiquinone, respectively

These early values for liver have now been supplemented by results, obtained by the co-operation of Dr I M Sharman and Miss Margaret Smith, on rat's hearts The hearts were taken from piebald males, which had received a diet deficient in vitamin E for eight months The severity of the deficiency was demonstrated in all the animals by the degeneration of their testes Since vitamin A does not accumulate in the heart in more than traces, it was unnecessary to restrict the intake of this vitamin, as is advisable when the liver is to be examined for ubiquinone The hearts were digested in alcoholic potash in the presence of pyrogallol as an additional protective agent[16], and the fraction containing ubiquinone was extracted with ether In spectrophotometric examination the maximum at 275 mμ seemed sharp enough to provide a rough indication of ubiquinone contents without further refinement of the extract A typical curve is shown in Fig 1, from which it will be seen that there was no inflexion at 330 mμ, the position indicative of substance *C* For four deficient rats, ubiquinone concentrations of 277–365, mean 338 μgm per gm of heart, were found Four similar rats, which had been given the same diet but with adequate doses of *dl*-α-tocopheryl acetate, had ubiquinone concentrations of 303–371, mean 331 μgm per gm of heart No evidence of an absorption maximum at 294 mμ, indicative of vitamin E, could be seen in heart extracts from either the rats deficient or adequate in vitamin E This was in line with our early experience[1] that the detection of vitamin E in liver extracts is prevented by ubiquinone even when vitamin A is absent

In these investigations, therefore, there was no indication of any relationship between the ubiquinone contents of the tissues and the vitamin E status Morton[7] has reached the same conclusion, but his evidence has not yet been published

[1] Moore, T , and Rajagopal, K R , *Biochem J* , **34**, 335 (1940)

[2] Martin, A J P , Moore, T , Schmidt, M , and Bowden, F P , *Nature*, **134**, 214 (1934)

[3] Ward, R J , and Moore, T , *Biochem J* , **59**, xvP (1955)

[4] Lowe, J S , Morton, R A , and Harrison, R G , *Nature*, **170**, 716 (1953)

[5] Heaton, F W , Lowe, J S , and Morton, R A , *Biochem J* , **60**, xviii (1955)

[6] Cunningham, N F , Lowe, J S , Mervyn, L , Morton, R A , and Vernon, J , *Biochem J* , **60**, xviii (1955)

[7] Morton, R A , *Nature*, **182**, 1764 (1958)

[8] Crane, F L , Hatefi, Y , Lester, R L , and Widmer, C , *Biochim Biophys Acta*, **25**, 220 (1957)

[9] Hatefi, Y , Lester, R L , and Ramasarma, T , *Fed Proc* , **17**, 238 (1958)

[10] Wolf, D E , Hoffman, C H , Trenner, N R , Arison, B H , Shunk, C H , Lunn, B O , McPherson, J F , and Folkers, K , *J Amer Chem Soc* , **80**, 4752 (1958)

[11] Lester, R L , Crane, F L , and Hatefi, Y C , *J Amer Chem Soc* , **80**, 4751 (1958)

[12] Hatefi, Y , Crane, F L , and Lester, R L , Abs 4th Internat Cong Biochem , 61 (1958) Pumphrey, A M , Redfearn, E R , and Morton, R A , *Biochem J* , **70**, 1P (1958)

[13] Nason, A , Vasington, F , and Donaldson, K O , Abs 4th Internat Cong Biochem , 61 (1958)

[14] Slater, E C , 4th Internat Cong Biochem , Contr to Symp XI (1958)

[15] Fahmy, N I , Hemming, F W , Morton, R A , Paterson, J Y F , and Pennock, J F , *Biochem J* , **70**, 1P (1958)

[16] Tosic, J , and Moore, T , *Biochem J* , **39**, 498 (1945)

MECHANISMS OF RESISTANCE OF ADULT HOUSEFLIES TO THE INSECTICIDE DIELDRIN

By F P. W WINTERINGHAM and A HARRISON
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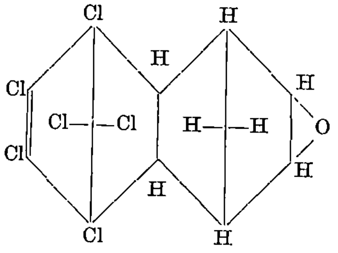
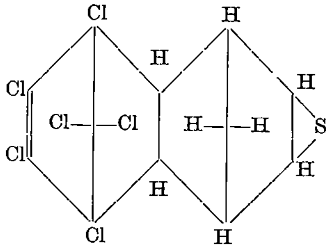
PENDING the successful syntheses[1] at this Laboratory of the insecticides labelled with carbon-14, the absorption, metabolism and excretion of the sulphur analogue labelled with sulphur-35 (II) of dieldrin (I) by dieldrin-resistant (*R*) and susceptible (*S*) adult houseflies (*Musca domestica*) have been studied Adults of the *S*-strain were from the normal laboratory stock Pupæ of the *R*-strain were obtained through the kindness of Dr J R Busvine and originally collected at Omdurman (Sudan)[2] The first generation of *R*-adults at this Laboratory (March 1957) displayed little resistance to topically applied I but after breeding through 6 generations on larval food containing I at a final concentration of 150 p p m the adults were highly resistant to either I or II when applied topically in acetone There was evidence of only a slight initial loss in resistance in adult *R*-flies after breeding through a further 19 generations in the absence of I

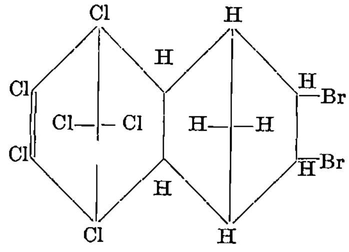
The radioactive insecticide (II) was applied topically to the dorsal thorax in 2 μl acetone to individual *R*- and *S*-adult flies while under mild *cyclo*propane anæsthesia and the flies kept in fresh air at 25° C without food or water for 3 hr Signs of poisoning appeared in *S*-flies alone towards the end of this period The flies were confined in groups of 10 or 20 to 1-in strips



(I)



(II)



(III)

of Whatman No 1 paper by means of shallow glass-covered cages so that almost all the excreta and vomit were collected on the paper Control groups were similarly set up in which the ani had been sealed to prevent excretion The difference between the radioactivities recovered on the normal and control papers thus represented net excretion , radioactivity of the control paper represented contamination by mechanical contact with the flies, vomit, etc After 3 hr the insects were anæsthetized and rinsed in acetone to remove unabsorbed insecticide Heads, thoraxes and abdomens were separately homogenized and extracted with acetone Acetone-insoluble metabolites were assayed in the extracted tissues Unchanged insecticide and metabolites were determined by radio-paper chromatographic techniques Only unchanged insecticide was recovered from flies which had been killed by heat before the experiment except for a small fraction present in all extracts which behaved as the sulphone of II under the conditions of paper chromatography used and is believed to arise largely through atmospheric oxidation The results of experiments in which 2 μgm of labelled II was applied to adult flies (50 males + 50 females) are collected in Table 1 This dose was lethal to all *S*-flies but innocuous with respect to *R*-flies The results were determined as ^{35}S-radioactivity, corrected for decay, self-absorption, etc , and expressed as a percentage of the dose applied

After 3 hr all the *S*-flies became prostrate and ceased to excrete , but metabolism of the absorbed insecticide continued for several hours, the metabolites accumulating mainly in the abdomen Resistant flies, on the other hand, continued to excrete their metabolites Thus, sealing of the anus had little effect on the accumulation of metabolites in the abdomen of the *S*-fly but a marked effect on that of the *R*-fly as shown graphically in Fig 1

Table 1 FATE OF (^{35}S) SULPHUR ANALOGUE OF DIELDRIN 3 HR AFTER TOPICAL APPLICATION TO DIELDRIN RESISTANT (*R*) AND SUSCEPTIBLE (*S*) ADULT HOUSEFLIES AT A DOSE OF 2 μGM PER INSECT

	S-strain Per cent applied dose	*R*-strain Per cent applied dose
Lost by volatility of insecticide* during treatment, manipulation, etc	34 3	27 2
Unabsorbed from cuticle	37 6	45 0
Unchanged insecticide in head	1 6	2 0
Unchanged insecticide in thorax	7 2	7 9
Unchanged insecticide in abdomen	6 6	6 2
Acetone-insoluble metabolites in head	0 2	0 1
Acetone-insoluble metabolites in thorax	1 0	0 7
Acetone-insoluble metabolites in abdomen	5 2	4 3
Unchanged insecticide excreted	3 4	2 7
Water-soluble metabolites excreted†	0 3	0 8
Water-insoluble metabolites excreted	0 5	0 9
Unchanged insecticide lost by mechanical contact and vomit	2 1	2 2
	100	100
Total effective detoxication stored metabolites + excreted metabolites and insecticide as per cent dose absorbed	38	35

* Determined by difference, but in one experiment a loss to the air of the insect chamber was demonstrated radiometrically

† Not sulphate

Some experiments were made with a non-insecticidal compound labelled with bromium-82 (III) so that metabolism and excretion of a related compound by *S*- and *R*-flies could be compared in the absence of toxic effects These experiments indicated that over a 24-hr period both strains excreted similar proportions of the unchanged compound together with small similar proportions of water-soluble metabolites

These experiments strongly suggest that resistance of the *R*-flies to dieldrin is not due to lack of cuticular penetration, or to a gross difference in the rates of excretion or metabolism of the insecticide by the *S*- and *R*-insects An efficient defensive mechanism is certainly operating in the *R*-insect during the first 3 hr because, towards the end of this period, the *S*-insect rapidly succumbed and there were signs of an irreversible lesion such as an exhaustive burst of respiration and fall of tissue α-glycerophosphate Other experiments at different dosages (0 37–5 μgm insecticide/insect), or of different duration (0 3–24 hr),

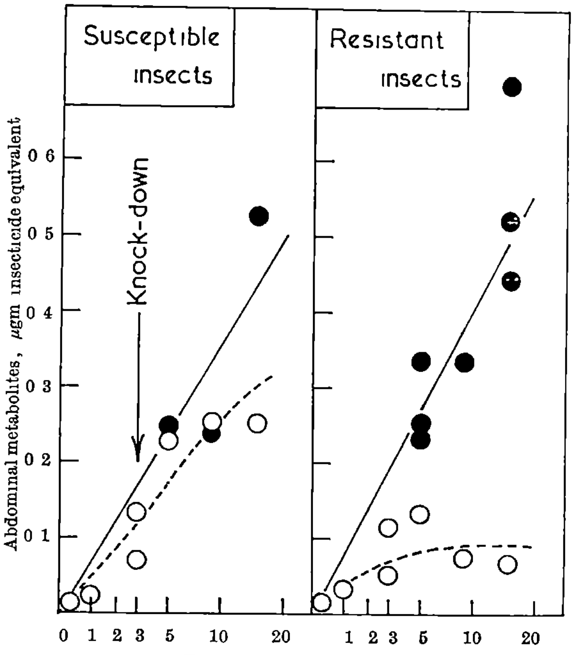


Fig 1 Accumulation of sulphur-35 metabolites in the abdomens of adult houseflies exposed to 2 μgm dieldrin-^{35}S analogue ○ - - - ○, excretion possible , ●—●, anus sealed, excretion not possible

or with an independent pair of S- and R-strains have led to the same conclusions

By chemical assay March, Metcalf and Baich (Metcalf, R L , personal communication) were unable to find any difference in cuticular penetration or in the apparent disappearance of absorbed dieldrin from their susceptible and resistant houseflies

The protective mechanism may be confined to particular sites, which involve only a small fraction of the absorbed insecticide For example, Yamasaki and Narahashi[3] found some evidence of a lowered sensitivity to dieldrin of the exposed thoracic ganglion of resistant houseflies which did not involve detoxication in other tissues

These experiments are part of an investigation into the mechanisms of dieldrin resistance in Diptera, supported in part by a research grant from the World Health Organization Full details will be published elsewhere

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[1] Brooks, G T , *J Chem Soc* , 3693 (1958)

[2] Busvine, J R , *Nature*, **174**, 783 (1954)

[3] Yamasaki, T , and Narahashi, T , *Botyu-Kagaku*, **23**, 146 (1958)

MOLECULAR SHAPE AND THE PHYSICAL PROPERTIES OF MUCIN

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EPITHELIAL mucin is an important secretion having somewhat unusual physical properties, and it has been shown, in two instances, that the materials responsible for these physical properties are so-called 'neutral' mucoids of the blood group substance type[1] Little is known at present of the molecular form of this class of compound , but evidence has been obtained, mainly from flow-birefringence measurements, indicating that these particular mucoids are molecules of the 'random-coil' type[1] It is of interest to re-examine some earlier work on mucoids of this type in the light of this result In particular, the physico-chemical data on the human blood group mucoids of Morgan and co-workers[2] may be re-considered These specimens were isolated from the same source and carefully purified using similar mild techniques, they differ in molecular weight over the range 2 6 × 10^5 to 1 8 × 10^6, but the chemical differences between them are, from the physico-chemical point of view, minor They may thus be taken to represent a homologous polymer series, something difficult to find elsewhere in the field of mucoid chemistry

Of the relationships known to exist between members of a homologous polymer series of random coils, two may be tested using published physico-chemical data The relationship between sedimentation coefficient at infinite dilution, s_0, and M, the molecular weight, should be of the form $s_0 = A + B\sqrt{M}$, where A and B are constants[3] Further, $\left[\frac{\mathrm{d}(1/s)}{\mathrm{d}c}\right]_{c \to 0}$ (c = concentration) should be independent of M as the following considerations will show Burger's equation for the variation of sedimentation rate of suspension of spheres with dilution has been found applicable to a number of polymers at low concentrations[4], as is reasonable in that the random coil molecule in translation approximates well to an impermeable sphere[3], due to the large amount of solvent it entrains within it

Taking $s = \frac{s_0}{1 + \Lambda\, nv}$, where Λ is a constant[4], n is the number of molecules per unit volume, and writing $\frac{Nc}{M}$ for n, where N is Avogadro's number, we have $\frac{1}{s} = \frac{1}{s_0} + \frac{\Lambda N c v}{s_0 M}$, so that $\frac{\mathrm{d}(1/s)}{\mathrm{d}c} = \frac{\Lambda N v}{s_0 M}$ Remembering that $s_0 = \frac{M(1 - \bar{v}\rho)}{N 6\pi\eta_0 a}$, and $v = \frac{4}{3}\pi a^3$, where a is the effective radius of the molecule and the other symbols have their usual significance, we may write the differential $\frac{8\,\Lambda\, N^2\pi^2\eta_0 a^4}{M^2\,(1 - \bar{v}\rho)}$. For a homologous polymer series in the same solvent, M is proportional to the square of any linear dimension of the molecule[5] Hence $\frac{a^4}{M^2}$ is constant in these conditions

The values of $s^0_{20,w}$ and $\frac{\mathrm{d}(1/s)}{\mathrm{d}c}$ given in Table 1 were obtained by extrapolation of the graph of $\frac{1}{s}$ against c to $c = 0$ A linear extrapolation was made although in the case of the first and third specimens quoted linearity is not good The values of $\frac{\mathrm{d}(1/s)}{\mathrm{d}c}$ given in Table 1 are thus averages between $c = 0$ and $c = 1$ per cent , furthermore, different degrees of polydispersity in the samples will cause some variation in the slopes observed, so that there is reasonable agreement with theory Linearity between s_0 and $\sqrt{M}$ is good The conclusion that these mucoids are of the random-coil form may be drawn with some confidence

It is interesting to note that the physical properties of mucin may be reasonably interpreted on the basis

Table 1 SEDIMENTATION COEFFICIENTS AND MOLECULAR WEIGHTS OF MUCOIDS

$s^0_{20,w} \times 10^{13}$	M	$\sqrt{M}$	$\frac{\mathrm{d}(1/s)}{\mathrm{d}c} \times 10^{-13}$*
8 9	2 6 × 10^5	509 9	0 72
9 1	2 7 × 10^5	519 6	0 75
10 0	3 2 × 10^5	565 6	0 91
12 3	4 6 × 10^5	678 2	0 80
25 0	1 8 × 10^6	1341 6	0 95

* c in gm /100 ml

Data from Kekwick (ref 2) and Caspery (ref 2) of what is already known of the properties of random coil molecules Epithelial mucin frequently gives rise to two phases in water, a rather dilute swollen gel phase and an aqueous phase which is almost pure water The gel phase displays visco-elastic or plasto-elastic rheological properties and may also show the Weissenberg effect These properties are entirely consistent with those of a random coil polymer below its Θ-point The gel phase may be dispersed to give a viscous solution by raising the pH, or the temperature, or by adding to the solvent a third component (for example, urea, calcium ions) Again, this behaviour is to be expected of a random-coil polymer if it contains potentially negatively charged groups, and if the solute-solvent interaction parameter[5] is increased by the addition of the third component

The physical properties of solutions of random-coil polymers have been extensively studied, and a good deal of the theoretical thermodynamic background is available , a full exposition is given by Flory[5] A consideration of this work may be of some value in the interpretation of the biochemistry and biophysics of mucous secretions, and attention is invited to three points (1) The molecular weights of mucoids may be determined from sedimentation coefficients and intrinsic viscosities, the latter being a more readily and more precisely determinable parameter than the more usual diffusion constant Moreover, axial ratio as usually evaluated from the frictional ratio is not meaningful with respect to this type of molecule (2) Where mucoids are modified by chemical treatment or by enzymes and a fall in viscosity is observed, this has usually been interpreted as a depolymerization Some caution is required here, since the change in viscosity may be largely due to chemical changes which alter the thermodynamic interaction parameter, or the related molecular expansion factor, and not necessarily to depolymerization (3) The degree to which the molecule is coiled up (that is, the molecular expansion factor) may effect the availability of antigenic sites on a mucoid molecule to antibody, and may be a factor concerned in its immunological reactivity

This work is part of a programme supported by the Population Council, Inc , Rockefeller Institute, New York

[1] Gibbons, R A , *Biochem J* (in the press)
[2] Kekwick, R A , *Biochem J* , **46**, 438 (1950) , **50**, 471 (1952), **52** 259 (1952) Caspery, E A , *ibid* , **57**, 295 (1954)
[3] Kuhn, H , and Kuhn, W , *J Polymer Sci* , **5**, 519 (1950)
[4] Wales, M , and Van Holde, K E , *J Polymer Sci* , **14**, 81 (1954)
[5] Flory, P J , "Principles of Polymer Chemistry" (Cornell University Press, 1953)

AN ASSOCIATION BETWEEN ABO BLOOD GROUPS AND FERTILITY IN A NORMAL AMERICAN POPULATION

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THE possibility of fertility differences associated with ABO blood group phenotype has been investigated in married couples in two populations[1,2], using couples unselected with respect to their fertility In 161 white American couples who had completed their families, fertility differences associated with blood groups could not be demonstrated[1] Such differences were found, however, in 1,429 Japanese couples of varying ages[2] A study of the fertility of 1,290 married English men and 1,319 married English women, age fifty years or more, failed to demonstrate an association between individual fertility and ABO blood group[3] We wish to record here observations on 558 white American couples in which fertility differences associated with blood groups do appear to be present

The present data were obtained from an investigation carried out for other purposes In the winter of 1950–51 a mass blood grouping (ABO and *Rh*) programme was carried out in Jackson County, Michigan, on 48,652 individuals by the Michigan Civil Defense[4] 72 per cent of the inhabitants of the city of Jackson (pop 51,088 in 1950) were included in this programme Blood from venepuncture was used and the ABO phenotypes were determined both by cell typing and back-typing of isoagglutinins In addition to ABO and *Rh* status, the name, address and religion were recorded for each individual For 64 per cent of the individuals, the date of birth was also noted , about 50 per cent of these persons were less than 15 years of age Family relationship was not recorded Afterwards, for the present analysis, the information on each individual was transferred to an I B M punch card and these cards were sorted by exact street address Whenever two or more persons having the same surname, street number, and street name in the city of Jackson were found, the city directory was consulted to determine if two of the persons were husband and wife If this was the case and there were other individuals of the same surname at this address, age relationships were examined to see whether these individuals could reasonably be children of the husband and wife Unless there was some definite indication, such as appropriate dates of birth, that this was so, the individual was not counted as a child of the couple Three thousand six hundred and twenty-eight 'families' were found Home interviews of 90 randomly chosen couples were made in the spring of 1958 to test whether these 'families' had been 'constructed' successfully The true number of children born by the time of the blood grouping to 53 couples in which the wife was born in 1910 or later was 79 , the number in our 'families' was 66, of whom 62 were correctly assigned, 1 was adopted, and 3 (all in one Negro family) were born out of wedlock but probably were the biological children of the couple For couples whose wives are in this age-range it is therefore probable that about 80 per cent of the actual children are correctly recorded

Table 1 DISTRIBUTION OF 558 MATINGS BY ABO BLOOD GROUP* AND NUMBER OF CHILDREN—WHITE PROTESTANT COUPLES IN WHICH THE WIFE IS 30-39 YEARS OF AGE

Mating Compatibility	Mating (♂ × ♀)	Number of children (= x) 0	1	2	3	4	5	6	7	8	Total number of couples	Total number of children	Mean number of children	S E of mean
Compatible	O × O	21	40	31	17	7	3	—	—	—	119	196	1 647	0 114
	O × A	19	21	38	22	3	5	—	—	—	108	200	1 852	0 122
	O × B	6	6	6	1	—	—	—	—	—	19	21	1 105	0 215
	O × AB	—	3	—	2	—	—	—	—	—	5	9	1 800	0 490
	A × A	18	28	22	14	4	2	—	—	—	88	140	1 591	0 132
	A × AB	1	1	3	1	—	1	—	—	—	7	15	2 143	0 595
	B × B	—	—	2	2	—	—	—	—	—	4	10	2 500	0 289
	Total	65	99	102	59	14	11	—	—	—	350	591	1 689	0 066
Incompatible	A × O	17	22	45	18	7	2	3	1	1	116	237	2 043	0 140
	A × B	3	5	8	4	2	1	—	—	—	23	46	2 000	0 274
	B × O	1	4	8	8	—	—	—	—	—	21	44	2 095	0 194
	B × A	7	5	5	—	1	1	1	—	—	20	30	1 500	0 387
	AB × O	1	3	4	2	—	—	—	—	—	10	17	1 700	0 300
	AB × A	2	3	6	4	—	—	—	—	—	15	27	1 800	0 262
	AB × B	—	—	3	—	—	—	—	—	—	3	6	2 000	—
	Total	31	42	79	36	10	4	4	1	1	208	407	1 957	0 097
All matings		96	141	181	95	24	15	4	1	1	558	998	1 789	0 055

* Matings ♂ B × ♀ AB and ♂ AB × ♀ AB did not occur

This communication reports on 558 couples which are Protestant, non-Slavic in surname, non-residents of the well-defined Negro district, and in which the wife is in the 30–39 year age group The first three restrictions reduce racial heterogeneity and ensure that, in the absence of natural selection, the probability that a given child was included in this study should be practically independent of the blood groups of his parents Various sources of error should also be independent of parental blood group (blood groups were not used in matching children and parents) The number of children recorded should therefore be proportional to the true number and valid comparisons of relative fertility can be made Women of completed fertility would ordinarily be preferable, but in these observations, they appear to be less fertile because their children often no longer reside in the parental home and so are missed

The distribution of couples by blood group and number of recorded children is given in Table 1 Analysis of variance of number of children, after suitable transformation of variable to correct for the non-normal distribution, can be used to test whether blood groups are related to fertility[1] This analysis is presented in Table 2 The transformation used $y = \sqrt{x + 1}$, where x is the number of children gives a distribution which does not differ significantly from the normal Bartlett's test indicates that the variances of y in the various matings are homogeneous Since all possible matings involving AB individuals are not represented, the analysis of variance was made on the 518 matings distributed among the 9 mating types involving A, B and O individuals

Table 2 ANALYSIS OF VARIANCE OF $y^* = \sqrt{x + 1}$, WHERE x IS NUMBER OF CHILDREN

Matings including AB individuals are omitted

Item	Degrees of freedom	Sums of squares	Mean squares	F ratio	P
Males	2	0 2819	0 1410	0 910	> 0 25
Females	2	0 3061	0 1531	0 988	> 0 25
Interaction	4	2 2658†	0 5665	3 657	< 0 01
Between matings	8	2 8538	0 3567	2 303	< 0 025
Within matings	509	78 8653	0 1549	—	—
Total	517	81 7191	0 1581	—	—

* Analysis of variance of x is similar, giving an interaction F of 3 242, $P < 0$ 025

† Obtained by subtraction The value obtained by fitting constants is 2 2908, giving an interaction F of 3 697

It is seen that the two main effects, males and females, are not significant, but that interaction (between males and females) is significant at the 1 per cent level This suggests that the significant difference between mating types in fertility is a property of the serological mating type and is not due to blood group differences among males or among females The biological interpretation of this result is not obvious, however, since (Table 1) the serologically incompatible matings (those in which the husband has an agglutinogen lacking in the wife) are significantly more fertile than the compatible matings ($P < 0$ 025, 2 tail test) In the Japanese study[2] the reverse was true, suggesting that ABO incompatibility is important in Japan, but in the previous American study[1], although significant differences were not found, the incompatible matings were more fertile It is not clear why this apparent difference between Japanese and American populations should exist The facts that (*a*) ABO incompatibility is known to be a protection against *Rh* hæmolytic disease of the newborn[5] and (*b*) 15 per cent of the American couples of the present study were of the incompatible mating type ♂($Rh+$) × ♀($Rh-$), while almost all the Japanese couples were ♂($Rh+$) × ♀($Rh+$), do not explain this difference This is shown by the fertilities of the following two types of couples in the present study *Rh* compatible and ABO compatible, 1 711 ± 0 072, *Rh* compatible and ABO incompatible, 2 047 ± 0 109 These means differ significantly at the 0 01 level

These results will be presented in more detail elsewhere We wish to thank the authorities of the Michigan Civil Defense for permission to analyse these results This study was supported by grant *AT* (11-1)-405 from the United States Atomic Energy Commission

[1] Reed, T E, and Kelly, E L, *Ann Hum Genet*, 22, 165 (1958)

[2] Matsunaga, E, and Itoh, S, *Ann Hum Genet*, 22, 111 (1958)

[3] Bennett, J H, and Walker, C B V, *Ann Hum Genet*, 20, 299 (1956)

[4] Ahronheim, J H, *J Amer Med Assoc*, 147, 1034 (1951), *Amer J Clin Path*, 21, 387 (1951)

[5] Levine, P, *Hum Biol*, 30, 14 (1958)

TABULAR COMPARATIVE DATA FOR THE LOW- AND HIGH-TEMPERATURE STRAINS OF *CHLORELLA*

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THE isolation of unicellular high-temperature algae began in Texas in 1951[1]. Some characteristics of the high-temperature strains are scattered in several publications[1-5]. To give a unified picture they are presented in Table 1 together with the unpublished results. It cannot be too strongly emphasized that, for a particular strain, cell characteristics are strongly influenced by external conditions both prior to (preconditioning) and during actual measurements. With many factors affecting cellular characteristics, only an attempt can be made to present results obtained under specified conditions for two strains each representative of a distinct biological group of algae: Emerson strain, representing the group of low-temperature algae, and *Chlorella* 7-11-05, representing the group of high-temperature algae.

A detailed description of the technique of studying characteristics depicted in Table 1 has been given in previous publications[3,4,6]. Only a few remarks are in place. Results of respiration and photosynthesis were obtained in manometric experiments of short duration with cells from liquid stock cultures grown under constant apparently optimal growth conditions for each strain. After a 20-min temperature adjustment period, readings were taken for 30 min and calculated as the rates of the process per 1 hr. Growth results were obtained in experiments of long duration. Inocula from the same stock cultures as used for manometric experiments were transferred into test-tubes and subjected to conditions specified in Table 1. An extended time and several transfers were often required to allow cells to pass the adjustment period. The actual measurements in individual experiments continued for a time sufficient for optical density of the algal suspension to rise from about 0.07 to 0.7. Incandescent bulbs were used as a source of light in growth and photosynthesis measurements. For both strains the illuminance in growth studies, as measured at the level of growth vessels, was 1,600 ft.-candles and in photosynthesis studies was about 2,000 ft.-candles.

Temperature optima for growth, indicated in Table 1, were obtained for both strains at illuminance above the light-saturating point. It should be emphasized that at lower light intensities the optimum for growth moves to lower temperatures and the upper limit extends to higher temperatures. Temperature optima and upper temperature limits for respiration and photosynthesis are higher in short-time manometric experiments than those for growth. However, it could be demonstrated that the dependence of metabolic characteristics on temperature is a time phenomenon. With the progress in manometric experiments the optima and maxima usually move to lower temperatures.

For endogenous respiration the importance of the time factor is augmented by the dependence of the rate of the process on the amount of respirable material left in algal cells. Even under optimal conditions the time course of endogenous respiration, as observed in manometric experiments, is described by falling rates. Our attempt to obtain values for endogenous respiration of cells, as they intensively grow under optimal conditions, produced much higher values—close to those of glucose respiration.

Values for the rates of glucose respiration, photosynthesis and growth are much more stable if

Table 1. TEMPERATURE CHARACTERISTICS OF TWO STRAINS OF *Chlorella pyrenoidosa*

Characteristic	Unit of measurement	Strain of *Chlorella* Emerson	7-11-05
(1)	(2)	(3)	(4)
Temperature optimum for			
growth	deg C	25–26	38–39
photosynthesis	,,	32–35	40–42
endogenous respiration	,,	30	40–42
glucose respiration	,,	30	40–42
Upper temperature limit for			
growth	deg C	29	42
photosynthesis	,,	39	45
endogenous respiration	,,	above 45	above 50
glucose respiration	,,	above 45	above 50
Growth rate at light saturation			
at 25° C	number of doublings per day	3.1	3.0
at 39° C	,, ,,	—	9.2
Growth rate at half saturating light intensity			
at 25° C	number of doublings per day	2.4	2.3
at 39° C	,, ,,	—	7.0
Rate of apparent photosynthesis at light saturation			
at 25° C	mm ^{3} O$_2$/mm ^{3} cells/hr	43	47
at 39° C	,, ,,	rapidly declining	170
Rate of apparent photosynthesis at half saturating light intensity			
at 25° C	mm ^{3} O$_2$/mm ^{3} cells/hr	32	30
at 39° C	,, ,,	—	115
Rate of endogenous respiration			
at 25° C	mm ^{3} O$_2$/mm ^{3} cells/hr	1.8	2.0
at 39° C	,, ,,	1.4	5.5
Rate of glucose respiration			
at 25° C	mm ^{3} O$_2$/mm ^{3} cells/hr	4.5	8
at 39° C	,, ,,	1.6	18
Saturating light intensity for growth			
at 25° C	ft.-candles	500	500
at 39° C	,,	—	1,400
Saturating light intensity for photosynthesis			
at 25° C	ft.-candles	400	500
at 39° C	,,	—	1,600

measured under optimal conditions for growth. This is true also for the high-temperature strain at 25° C. It is noticed that at 25° C. the rates of growth, respiration and photosynthesis are close or slightly higher for *Chlorella* 7-11-05 than for the Emerson strain. However, if compared at a temperature optimal for their growth, the Emerson strain has about 3 doublings and *Chlorella* 7-11-05 more than 9 doublings of cell material per 24-hr. period. With further refining of the technique, 10 doublings per day are readily obtainable. This gives an 8-fold increase of cell material for a 24-hr. period for the Emerson strains and 1,000-fold increase for *Chlorella* 7-11-05. The rate of photosynthesis in the high-temperature algae is 4 times higher at light saturation than in low-temperature algae and 3.6 times higher at half-saturation. For growth the corresponding figures are 3 and 2.9.

The greater productivity of higher-temperature algae in comparison with low-temperature strains is due to the ability of the high-temperature algae to use higher temperature and illuminance levels. This is indicated by much higher positions of light-saturating points for growth and photosynthesis in the higher-temperature algae. The suggestion, that for the low-temperature strain the saturating light intensity for growth is slightly higher than that for photosynthesis and for the high-temperature strain the relationship is reverse, is probably of no significance since the determination of light-saturating intensity involves some degree of approximation.

A most general characteristic of the high-temperature algae is their higher responsiveness to the increase (within limits) in temperature and in incident light energy. In this respect they actually are higher-efficiency algae. The term 'efficiency' here is an expression of two processes—the absorption of the incident energy and conversion of the absorbed energy into the product which is used for measuring the rate of the process. Its pragmatic usefulness is based on the fact that it describes the performance of the organism at high levels of temperature and light energy. The highest levels of the incident energy are of utmost importance for the organism of high productivity capable of using temperatures and light intensities which are of no use if not harmful for the low-efficiency (low-temperature) strains.

The work has been supported by grants from the Office of Naval Research.

Many helpful contributions by Drs. Jack Myers, Robert W. Krauss and Hugh G. Gauch during the course of investigations or in reviewing the manuscript are gratefully acknowledged.

Contribution No. 2970, Maryland Agricultural Experiment Station, Scientific Article *A* 729.

[1] Sorokin, C., and Myers, J., *Science*, **117**, 330 (1953).

[2] Sorokin, C., in W. S. Spector's (ed.) "Handbook of Biological Data" (National Academy of Sciences, National Research Council, 1956).

[3] Sorokin, C., *Physiol. Plantarum*, **11**, 225 (1958).

[4] Sorokin, C., and Krauss, R., *Plant Physiol.*, **33**, 109 (1958).

[5] Sorokin, C., *Physiol. Plantarum*, **10**, 659 (1957).

[6] Sorokin, C., and Myers, J., *J. Gen. Physiol.*, **70**, 579 (1957).

PHOTOCHEMICAL AND STEREOCHEMICAL PROPERTIES OF CAROTENOIDS AT LOW TEMPERATURES

By STAFF OF THE BIOLOGICAL LABORATORIES OF
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IN this series of articles we report the results of measurements carried on in this laboratory over the past six years. They involve the absorption spectra of carotenoids and haplo-carotenoids (vitamin A, retinene) at temperatures between 25° and − 196° C. The most important single result of these measurements is to demonstrate that cooling such molecules relieves certain instances of steric hindrance ('intramolecular overcrowding')[1], with large effects upon the absorption spectrum and other properties.

The first communication records three observations which, though all made with retinene, have some general interest: (1) the abnormally large changes exhibited by the absorption spectrum of a sterically hindered *cis* carotenoid on cooling; (2) the capacity of a carotenoid to undergo *cis–trans* isomerization at low temperatures in a rigid solvent; and (3) a more specific observation, a new instance of reversible photobleaching.

In the second communication we examine further the first of these phenomena, and show that the absorption spectra of all-*trans* and unhindered-*cis* configurations of retinene, vitamin A, vitamin A_2, lycopene and β-carotene exhibit parallel changes on cooling; whereas those of sterically hindered configurations of these molecules display the abnormally large changes first observed with retinene alone. The third communication discusses the significance of these observations.

(1) Photochemical Behaviour of Retinene

By DR. LAWRENCE JURKOWITZ

IN these experiments retinene (vitamin A aldehyde, $C_{19}H_{27}CHO$; Fig. 1) was dissolved in the mixtures of ether, isopentane or isohexane (3-methyl pentane) and alcohol (5:5:2) called *EPA* and *EHA*[2]. Such solutions were brought to temperatures close to that of liquid nitrogen (− 196° C.), at which *EPA* and *EHA* become so highly viscous as to form what are essentially clear glasses.

The measurements were made in a Dewar flask designed by Dr. R. C. C. St. George, mounted in a special housing which could be substituted for the standard cell compartment of a Beckman *DU* spectrophotometer. The Dewar flask was silvered throughout except for a clear band at the level of the light path, serving as window. It was made of

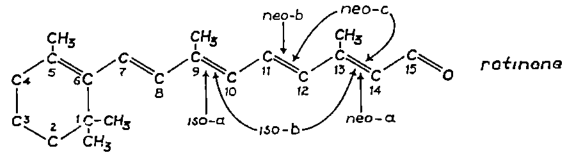


Fig 1 Structural formula of all-*trans* retinene Above and below the formula are indicated the positions of the *cis* linkages in known geometrical isomers Unhindered isomers below iso-a (9-*cis*), neo-a (13-*cis*), and iso-b (9,13-*dicis*) Sterically hindered isomers above neo-b (11-*cis*) and neo-c (11, 13-*dicis*)

'Pyrex' glass, and had a high transmission only for wave-lengths longer than about 320 mμ The Dewar was blown in the form of an H, with two vertical chambers connected by a horizontal section One of the chambers held the absorption cell Liquid nitrogen could be added from time to time through the other chamber without disturbing the absorption vessel, and this also provided an additional store of the coolant, which for this reason needed to be replenished less often The absorption cell could be lowered and raised, into and out of the light path of the spectrophotometer, and all measurements were made with the cell alternately in these positions That is, all absorptions were measured relative to the absorption of the Dewar flask without the absorption cell in position The level of liquid nitrogen was at all times below the absorption cell, and hence out of the path of light A 'blank' correction was obtained by measuring separately the absorption spectrum of the cell containing solvent alone under the same conditions A further correction involves the contraction of the solvent at low temperatures *EPA* and *EHA* were observed to contract fairly regularly on cooling Their volume at −190° is about 0 77 of that at room temperature The temperature of the solution in the absorption cell was followed continuously with an iron-constantan thermocouple immersed in it

All irradiations were performed with a high-pressure mercury arc lamp (General Electric *AH*5, 250 watts) mounted so that its radiation, having passed through a 'Lucite' cell containing a layer of water 2 5 in thick, could be focused with a glass lens directly upon the solution in the absorption cell The full radiation of the arc was employed, but enough glass lay between the lamp and the absorption cell to exclude wave-lengths shorter than about 320 mμ

(1) *Relief of steric hindrance at low temperatures* Retinene owes its absorption spectrum to the possession of five double bonds—four in the side-chain and one in the attached ring—all in some degree of conjugation with one another and with the terminal carbonyl group (Fig 1) The molecule exists in a variety of geometric configurations—*cis–trans* isomers —the most prevalent of which have been isolated, and their configurations established by synthesis[3] These include the all-*trans* isomer, the relatively unhindered 9- and 13-*monocis*, and 9, 13-*dicis* isomers, and the sterically hindered 11-*cis*, and 11, 13-*dicis* isomers (Fig 1)[4] The hindered 11-*cis* isomer (called also neo-b) has a special interest, since this configuration of retinene and retinene$_2$ serves as the chromophore of all the known visual pigments[5]

The absorption spectrum of all-*trans* retinene at room temperature consists of a single broad band, maximal in *EPA* at about 373 mμ (λ_{max}), and with a molar extinction coefficient, ε_{max}, of 47,600 (Fig 2) Brought to about − 185°, the absorption spectrum still displays no fine structure, but λ_{max} moves about 14 mμ toward longer wave-lengths, and ε_{max}, rises about 10 per cent Also the long wave-length toe or tail of the band is drawn in toward shorter wave-lengths Such changes are characteristic of polyenes brought to low temperatures (cf ref 6, also following communication)

The same experiment performed with the sterically hindered 11-*cis* isomer yields a very different result (Fig 2, right) A primary consideration that governs the behaviour of such molecules is the degree to which they achieve coplanarity, that is, to which they succeed in lying flat Only when coplanar can their systems of alternate single and double bonds come into full conjugation, the condition in which the absorption spectrum lies at longest wave-lengths, displays the most detailed fine structure, and has the largest maximal and integrated extinction Any loss of coplanarity—any twisting of the system—results in a loss of conjugation, with corresponding losses of extinction and fine structure, and usually also a shift of spectrum toward shorter wave-lengths

A *cis* linkage at position 11, since it brings into conflict the H atom on carbon 10 and the $-CH_3$ group on carbon 13, prevents coplanarity, causing a twist in the molecule at this level The result (Fig 2) is a considerable degradation of spectrum at room temperature, evident mainly in the depression of ε_{max} to 26,400—only 0 555 the ε_{max} of the all-*trans* isomer λ_{max} also lies at slightly shorter wave-lengths than in the all-*trans* isomer (at 369 mμ), a remarkably small change compared with other hindered *cis* polyenes[7]

On cooling to temperatures near that of liquid nitrogen, both λ_{max} and ε_{max} change so greatly as to approach the values observed in all-*trans* retinene at these temperatures λ_{max} shifts to about 385 mμ, and ε_{max} increases to about 43,000 (Fig 2, right) That is, whereas cooling to − 185° raises the ε_{max} of all-*trans* retinene about 10 per cent, it raises that of 11-*cis* retinene 62 per cent These changes are entirely reversed on warming It should be noted that the temperature to which we have brought these solutions is arbitrary, further cooling presumably would result in a further approximation of the 11-*cis* to the all-*trans* spectrum

It is as though cooling to about − 185° had largely relieved the steric hindrance associated with a *cis* linkage in position 11 This interpretation of

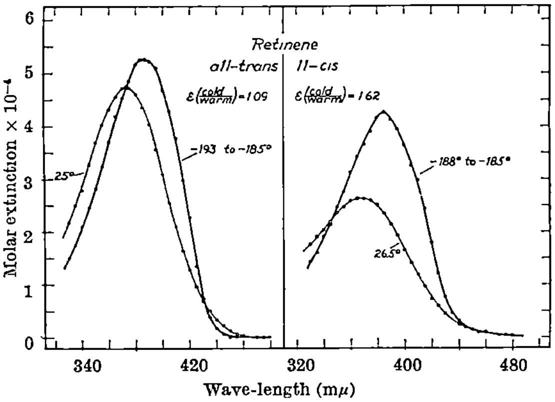


Fig 2 Absorption spectra of all-*trans* and 11-*cis* retinene, at room temperature and at that of liquid nitrogen Cooling raises the ε_{max} of the all-*trans* isomer 9 per cent, and that of the hindered 11-*cis* isomer 62 per cent

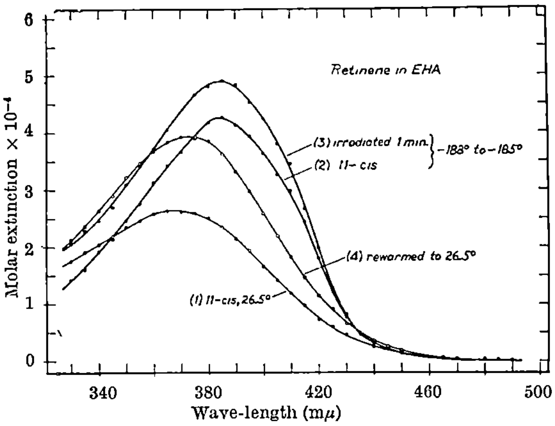


Fig 3 Geometrical isomerization of retinene by light at a low temperature in a rigid solvent (1) Absorption spectrum of 11-*cis* retinene in *EHA* at room temperature (2) Same at the temperature of liquid nitrogen, the solvent is vitrified (3) Irradiated 1 min in the cold (4) Returned to room temperature, in the dark The rise of ϵ_{max} in the cold, accentuated in the warm, is associated with the isomerization of the hindered 11-*cis* isomer to a steady state mixture of all possible isomers, primarily all-*trans*

the observations is pursued further in the communication which follows

(2) *Cis–trans isomerization* Retinene is isomerized by simple exposure to light Beginning with any single geometric isomer, this process ends with the production of a steady-state mixture of all possible isomers, the proportions of which vary with solvent and other conditions, but the major component of which is usually all-*trans*[8]

It occurred to us to ask whether this process would be inhibited by low temperatures, perhaps because it includes a thermal component[9], or by being carried out in a rigid solvent, which might restrict the necessary rotation about double bonds It should be noted that geometric isomers of retinene in the crystalline state are not isomerized, even by long exposure to bright sunlight (It must be conceded that our experiments to date leave it undecided whether this is owing to the crystalline state itself, or to failure of light to penetrate the crystal The specific extinction of retinene is so high that at λ_{max} the intensity of light is cut to 1 per cent after penetrating only about 0 12μ of the pure substance, so that the interior of even a small crystal might scarcely be affected by even a long and intense irradiation)

In the present experiment we used 11-*cis* retinene, which, being a hindered isomer and relatively unstable, isomerizes almost completely and with a particularly large change of extinction[8,10] A solution of 11-*cis* retinene in *EHA* was brought to about – 187°, and irradiated for 1 min (Fig 3) The extinction rose about 16 per cent, λ_{max} remaining almost unchanged On warming the product to room temperature, these changes were magnified compared with the spectrum before irradiation, the extinction had risen 1 5 times, and λ_{max} had shifted about 5 mμ toward longer wave-lengths, arriving close to the λ_{max} of all-*trans* retinene These are the changes that characteristically accompany the isomerization of neo-b retinene to the steady state mixture of isomers, primarily all-*trans*

All-*trans* retinene behaves very differently under these conditions On irradiation in *EHA* for 1 min at about – 185°, the extinction of this isomer falls about 2 per cent, and on re-warming to room temperature, the spectrum compared with that before irradiation had fallen 1 3 per cent in extinction, with no appreciable change in λ_{max} Once again, this behaviour is characteristic of the isomerization of the all-*trans* isomer to a mixture containing small amounts of *cis* isomers, all lower in extinction

It may be concluded that neither the low temperature nor a rigid solvent inhibits the geometric isomerization of this molecule The process appears to go about as well in these circumstances as at room temperature Apparently the rigid solvent leaves the molecule sufficient 'elbow room' to allow free play for the rotations involved in geometric isomerization

(3) *Reversible photo-bleaching* In this experiment, all-*trans* retinene in *EPA* was brought to the temperature of liquid nitrogen, and exposed to the full radiation of the mercury arc As stated earlier, however, only wave-lengths longer than 320 mμ penetrated to the sample It should be noted that no particular precautions were taken to exclude oxygen or water vapour

The effects of the irradiation are shown in Fig 4 In 30 min the maximum extinction, at 387 mμ, had fallen to about 60 per cent, and in another 30 min to about 20 per cent of its initial value Small new maxima had appeared at about 350 and 412 mμ

On re-warming this solution to room temperature, the absorption rose again, not indeed to its original height at room temperature, yet to 87 per cent of it, and λ_{max} returned approximately to its original position Some of the fall in final extinction is caused by isomerization, owing to the irradiation, from the all-*trans* configuration to the steady state mixture of isomers already described, the remainder probably involves some destruction of pigment

The major change in this experiment, however, was the photo-bleaching at low temperature, reversed (except for the concomitant isomerization) on re-warming to room temperature The same phenomenon has been observed also with all-*trans* retinene dissolved in *EH* amine (ether, isohexane, triethylamine, 5 5 2) On irradiation at about – 187°, the extinction falls, and a new maximum develops at about 350 mμ and a minimum at about 368 mμ Again, on warming, these changes are largely

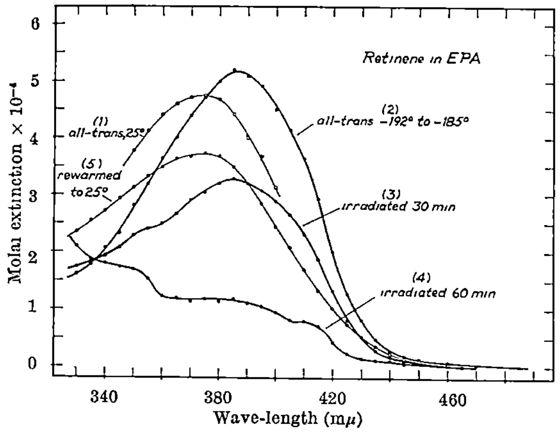


Fig 4 Reversible photobleaching of retinene at low temperature in a rigid solvent (1) All-*trans* retinene in *EPA* at room temperature (2) Same brought to liquid nitrogen temperature (3) Irradiated 30 min in the cold, ϵ_{max} falls 40 per cent (4) Irradiated 30 min longer, ϵ_{max} has fallen 80 per cent (5) Rewarmed to room temperature in the dark Most of the original extinction is regained, what has been lost is due mainly to the light having isomerized the all-*trans* retinene to a steady state mixture of *cis* and *trans* forms

reversed, the band at 350 mμ disappearing, and the retinene band rising to nearly its original height. On the other hand, similar experiments with retinene$_2$ dissolved in *EPA* and *EH* amine have not displayed photo-bleaching.

This photo-bleaching of retinene resembles somewhat, in the character of the spectral change, the production of a metastable (triplet ?) state in chlorophyll by exposure to a brief, very intense flash of light[11]. The present product, however, appears to be too long-lived to represent a triplet state. It may correspond rather to the formation of a pair of free radicals or ions, trapped in the rigid solvent, but able to recombine on warming to reconstitute normal retinene. In this regard the reversible photo-bleaching of retinene may resemble another mode of photo-bleaching of chlorophyll, discovered some years ago by Porret and Rabinowitch[12], yet which demanded a degree of exclusion of oxygen probably not achieved in the present experiments.

(2) *Cis-trans* Isomerism and Steric Hindrance

By JOHN N. LOEB, PAUL K. BROWN and PROF. GEORGE WALD

HAVING observed one instance in which cooling to the temperature of liquid nitrogen largely abolished the degradation of spectrum associated with a sterically hindered *cis* linkage, we wished to learn how general this phenomenon may be, and how related to other aspects of molecular geometry. With this object in view, we have examined the spectra of geometrical isomers of retinene, vitamin A and A$_2$, lycopene and β-carotene at room temperature and at that of liquid nitrogen. The procedures were as already described, except that for the measurement of vitamin A we used a quartz Dewar flask and quartz absorption cell in place of the 'Pyrex' vessels used otherwise.

(1) *Retinene*. The most extensive set of geometric isomers of known constitution now available is offered by the stereoisomeric retinenes. We have already described the changes of spectrum on cooling the all-*trans* and the hindered 11-*cis* isomer. In the present experiments these measurements were extended, and similar measurements performed with the relatively unhindered 9-*cis*, 13-*cis* and 9,13-*dicis* isomers (Fig. 1)[3b]. These measurements are summarized in Table 1, and the changes of extinction with temperature are shown in Fig. 5.

As already noted, the all-*trans* isomer on cooling to about – 185° C. exhibits a displacement of λ_{max} of about 14 mμ toward longer wave-lengths, and a rise of ε_{max} of about 10 per cent. Very nearly the same changes are displayed by all the unhindered *cis* isomers, so that they, together with the all-*trans* isomer, show on this degree of cooling an average displacement of λ_{max} of 13 mμ, and an average rise of ε_{max} of 11 per cent. This correspondence in behaviour is evident in Fig. 5 in the close parallelism of the lines describing the change of ε_{max} with temperature for these isomers.

The extraordinary behaviour of the 11-*cis* isomer is especially evident in this context. To examine this more closely we have measured the spectra of all-*trans* and 11-*cis* retinene at intermediate temperatures between 25° and – 185° C.; the variations of ε_{max} over this temperature range are included in Fig. 5.

On cooling all-*trans* retinene, ε_{max} rises linearly over the entire range of temperatures. The 11-*cis* isomer exhibits altogether different behaviour. Having begun at room temperature far below that of any of the other *cis* isomers, the ε_{max} of 11-*cis* retinene rises so rapidly on cooling that by the temperature of liquid nitrogen it has become higher than that of the unhindered 9,13-*dicis* isomer, and as high as those of the unhindered 9- and 13-*monocis* isomers. One would expect that having achieved this position, ε_{max} should continue to rise at still lower temperatures in parallel with the rise of the unhindered *cis* isomers; yet this would demand a considerable decrease in slope, of which there is no hint in the data of Fig. 5. Indeed, the rise of ε_{max} in the 11-*cis* isomer proceeds in two stages, each linear with temperature, a relatively slow change from room temperature to about – 100°, and a considerably more rapid further change to about – 185°. The significance of the break in the curve and change of slope is not yet clear; but it makes all the more problematical the course of this function at still colder temperatures.

Incidentally, these measurements show that the effects of cooling are regular and continuous. They go primarily, therefore, with the change of tem-

Table 1. EFFECTS OF COOLING UPON CAROTENOID SPECTRA

Geometric isomer	Room temperature ε_{max} (× 10^{-3})	Room temperature λ_{max} (mμ)	– 185° to – 195° ε_{max} (× 10^{-3})	– 185° to – 195° λ_{max} (mμ)	Ratio of ε_{max} (cold/warm)	Shift of λ_{max} (cold – warm) (mμ)
Retinene						
All-*trans**	47.6	373	51.7	387	1.09	14
9-*cis*	39.7	366	44.1	379	1.11	13
13-*cis*	38.8	366	43.5	380	1.12	14
9,13-*dicis*	35.6	360	39.9	371	1.11	11
(Retinene$_2$, all-*trans*)	42.0	392	45.5	409	1.09	17
11-*cis* (hindered)†	26.4	369	43.0	384.5	1.63	15.5
β-Carotene						
All-*trans*‡	137.5§	451.5	184	469	1.34	17.5
15-*monocis*	98.3	447	140	465	1.42	18
(Lycopene, all-*trans*)‡	186	472	272	484	1.46	12
11,11′-*dicis*	46.2	403	134	452.5	2.90	49.5
Vitamin A						
All-*trans*	52.1	324	54.2	333.5	1.04	9.5
(Vitamin A$_2$ acetate, all-*trans*)	39.5	349	45.0	360	1.14	11
11-*cis*	34.3	318	48.7	332.5	1.42	14.5

* Averages from three sets of measurements.
† Averages from four.
‡ Averages from two.
§ For carotene and lycopene, ε_{max} and λ_{max} are of the 'middle' maximum, that of next-to-longest wave-length.

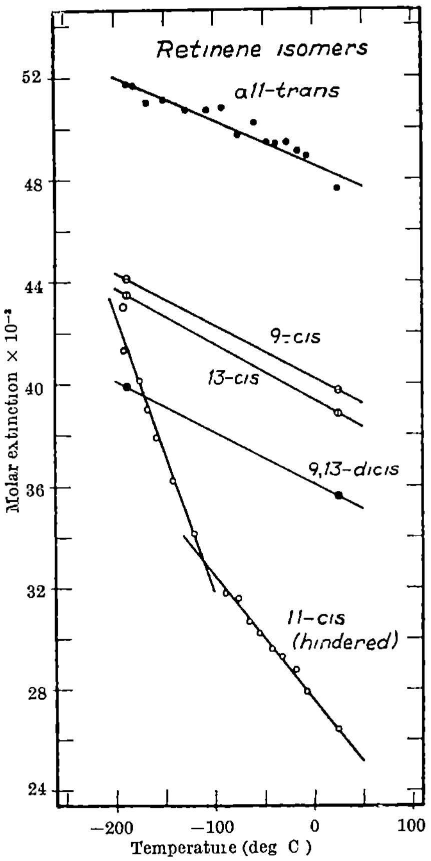


Fig 5 Rise of maximum extinction (ε_{max}) of geometric isomers of retinene on cooling to liquid nitrogen temperature The all-*trans* and unhindered *cis* isomers exhibit parallel changes, ε_{max} rising on the average 11 per cent In the hindered 11-*cis* isomer, ε_{max} rises in two linear stages, a total of 62 per cent The significance of the break in the latter function is not known

perature and not with vitrification of the solvent, which becomes apparent only at very low temperatures, below − 160°

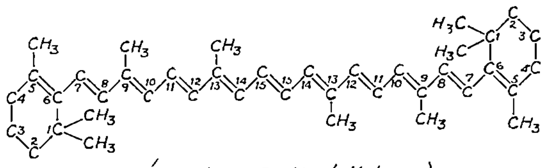
It is a striking characteristic of the 11-*cis* isomer that though its sterically hindered configuration greatly depresses ε_{max}, it has little effect on λ_{max}, which is displaced from the all-*trans* position no more than in other *monocis* configurations By the same token, cooling has no greater effect on the λ_{max} of the 11-*cis* isomer than on the others Furthermore, the change of λ_{max} with temperature for this as for the other isomers is simple and linear, with no evidence of such a break as appears in the function for ε_{max}

(2) β-*Carotene* The spectrum of all-*trans* β-carotene ($C_{40}H_{56}$, Fig 6) exhibits three absorption maxima in the visible region, the central one of which has the highest extinction (Fig 7) These maxima constitute vibrational fine structure superimposed upon a broad absorption band which represents a single electronic transition from the ground to the first electronically excited state On cooling to the temperature of liquid nitrogen, the spectrum as a whole is displaced toward longer wave-lengths, and the fine structure is greatly accentuated, five maxima now being distinguishable Now also the absorption maximum of longest wave-length has the highest extinction Ordinarily in carotenoid spectra the band of next-to-longest wave-length is highest, and this maximum also can most readily be compared with cases in which no vibrational fine structure appears, the entire absorption taking the form of a single, broad band For these reasons our measurements are summarized in Table 1 and Fig 8 in terms of the central maximum A more significant index is the area under the entire absorption band A comparison on this basis is shown in Table 2 (below).

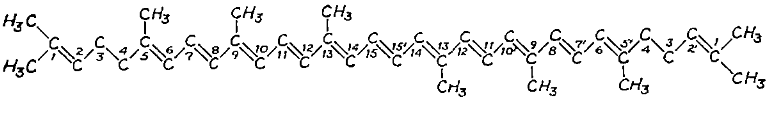
On cooling to about − 185°, the central maximum in all-*trans* β-carotene is displaced about 17 mμ toward longer wave-lengths, and rises 32 per cent in extinction Similar measurements were made upon all-*trans* lycopene, $C_{40}H_{56}$, the straight-chain isomer of β-carotene (Fig 6) with similar results (Table 1) On cooling, its central maximum was transposed about 12 mμ toward longer wave-lengths, and the extinction rose 46 per cent

As an example of an unhindered *monocis* β-carotene, we have examined the 15,15′-*monocis* isomer (hereafter called 15-*cis*), prepared synthetically[13] Such a centrally placed *cis*-linkage causes a maximum bending of the molecule, and is associated with a particularly tall '*cis*-peak'[14] in the near ultra-violet at about 340 mμ The ε_{max} of 15-*cis* β-carotene is only 71 per cent as high as that of the all-*trans* isomer, but on cooling to about − 185°, this spectrum undergoes parallel changes (Fig 8) Once again λ_{max} is displaced 16 mμ toward longer wave-lengths, and ε_{max} rises 42 per cent. As in the retinenes, cooling has about the same effect on the unhindered *cis* isomer as on the all-*trans* configuration

15-*monocis* β-carotene offers a particularly good opportunity to examine the effects of cooling upon a *cis*-peak At room temperature the *cis*-peak of this molecule consists of a single band, maximal at about 335 mμ in *EPA*, and with ε_{max} 58,500, almost 60 per cent as high as the main absorption band On cooling to about − 185°, the maximum moves to about 349 mμ—a shift of about 14 mμ, slightly less than in the main band—and ε_{max} rises about 9 per cent—very much less than in the main band This difference in the effect of cooling on ε_{max} is probably



β-carotene, $C_{40}H_{56}$ (all-trans)



lycopene, $C_{40}H_{56}$ (all-trans)

Fig 6 Structures of all-*trans* β-carotene and lycopene These isomeric carotenoid hydrocarbons differ mainly in that lycopene is straight-chain, whereas β-carotene possesses terminal β-ionone rings The latter are twisted out of coplanarity with the side-chain, owing to steric hindrance between the methyl groups at 1, 1′ and the H atoms at 8, 8′, so causing a large loss of conjugation of the ring double bonds with the straight-chain portion of the molecule

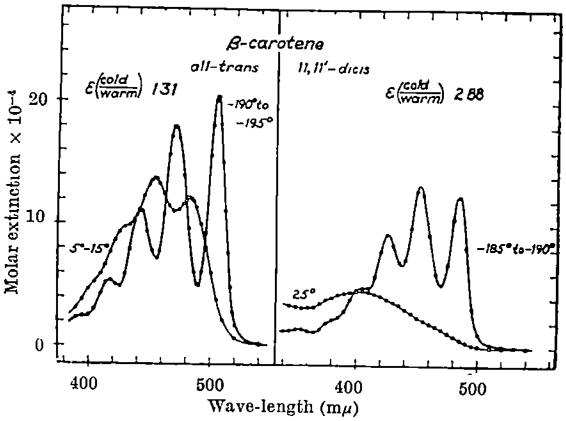


Fig. 7. Absorption spectra of all-*trans* and 11,11'-*dicis* β-carotene in *EPA* at room temperature and at that of liquid nitrogen. On cooling, the maximal extinction of the 'middle' band (that of next-to-longest wave-length) rises 31 per cent in the all-*trans* isomer, and 188 per cent in the hindered *cis* isomer. The spectra measured in the cold display five distinct maxima, representing transitions from the 0 vibrational level of the ground electronic state to five vibrational levels of the first electronically excited state

not very significant; in both cases the area of the band remains practically unchanged (cf. Table 2). On the whole, it may be concluded that the effect of cooling is much the same on the *cis*-peak as on the long-wave-length absorption.

As in the retinenes, however, a hindered *cis* isomer behaves very differently. As example of such a form we have examined 11,11'-*dicis* β-carotene, prepared synthetically[15]. This molecule contains, symmetrically placed, two hindered *cis* linkages like that of 11-*cis* retinene. The absorption spectrum in the visible region is greatly degraded at room temperature, consisting of a single broad band displaying no fine structure, with ε_{max} only 33.6 per cent as high as that of all-*trans* β-carotene, and λ_{max} displaced about 50 mμ toward shorter wave-lengths (Fig. 7). On cooling to about − 185°, this spectrum changes out of all proportion with the all-*trans* and 15-*cis* isomers: ε_{max} rises 2.90 times, approaching close to the ε_{max} of 15-*monocis* carotene (Table 1, Fig. 8), and λ_{max} is displaced 49.5 mμ towards longer wave-lengths. In addition, the spectrum in the cold exhibits all the fine structure characteristic of unhindered isomers of β-carotene. As with 11-*cis* retinene, there is every appearance that cooling to this degree has almost wholly relieved the steric hindrance.

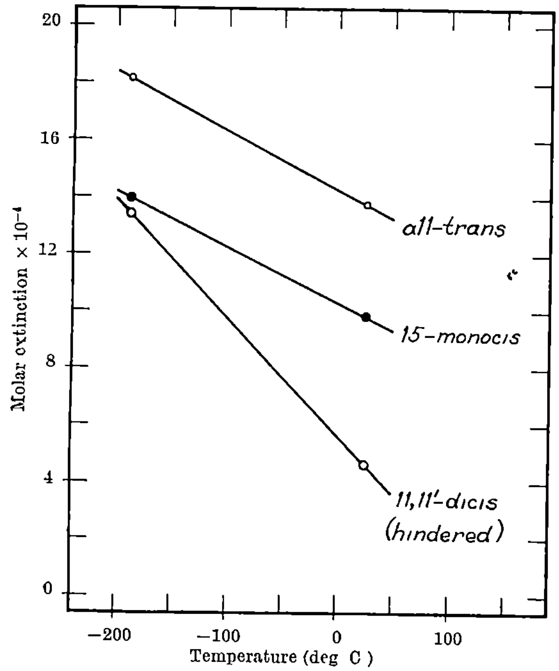


Fig. 8. Effect of cooling on the maximal extinction of geometric isomers of β-carotene. The ε_{max} recorded is that of the 'middle' (next-to-longest wave-length) band. The changes in the all-*trans* and unhindered 15-*cis* isomers are nearly parallel. The hindered *cis* isomer exhibits a much larger change

(3) *Vitamin A*. The attempt to perform similar measurements with vitamin A ($C_{19}H_{27}CH_2OH$) encounters special difficulties. These measurements must extend further into the ultra-violet than with the other polyenes; hence we transferred to a quartz Dewar flask and quartz absorption cell. Unfortunately also, a large solvent 'blank', and consequent impairment of the accuracy of measurement, develop below 330 mμ.

What is more troublesome is that vitamin A fluoresces strongly at room temperature, and brilliantly at the temperature of liquid nitrogen. In the Beckman spectrophotometer as ordinarily employed, much of the fluoresced light is picked up by the photocell, and recorded as if it were a decrease of extinction. The error so introduced is negligible at room temperature, but considerable in the cold, both because of the increased fluorescence, and because the need to open the slit of the spectrophotometer widely at short wave-lengths greatly increases the radiation incident on the solution. In our first measurements, having done nothing to temper this effect, we were surprised to find that, unlike all the other polyenes measured, vitamin A appeared not to rise in extinction on cooling. In the later measurements to be described, we inserted a Jena *UG*-1 filter, which transmits light only between about 320 and 400 mμ, between the Dewar flask containing the absorption cell and the photocell, so removing at least the visible fluorescence. This helped somewhat to bring the measurements on vitamin A into line with those on other polyenes, but was not wholly adequate, since fluorescence in the near ultra-violet still reached the photocell.

The absorption spectra of all-*trans* and 11-*cis* vitamin A, measured in *EPA* at room temperature and in the cold, are shown in Fig. 9. The changes in λ_{max} and extinction which occur on cooling are summarized in Table 1 and Fig. 10.

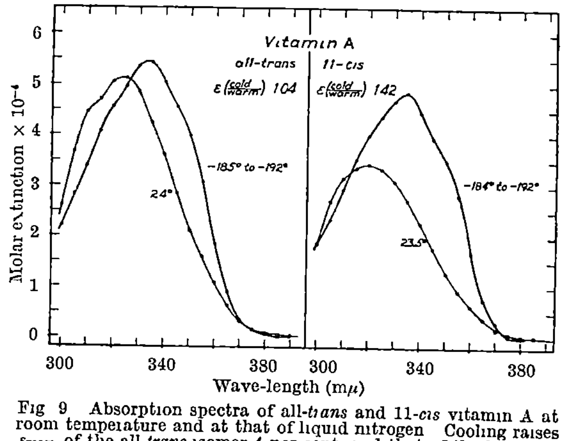


Fig. 9. Absorption spectra of all-*trans* and 11-*cis* vitamin A at room temperature and at that of liquid nitrogen. Cooling raises ε_{max} of the all-*trans* isomer 4 per cent, and that of the hindered *cis* isomer 42 per cent

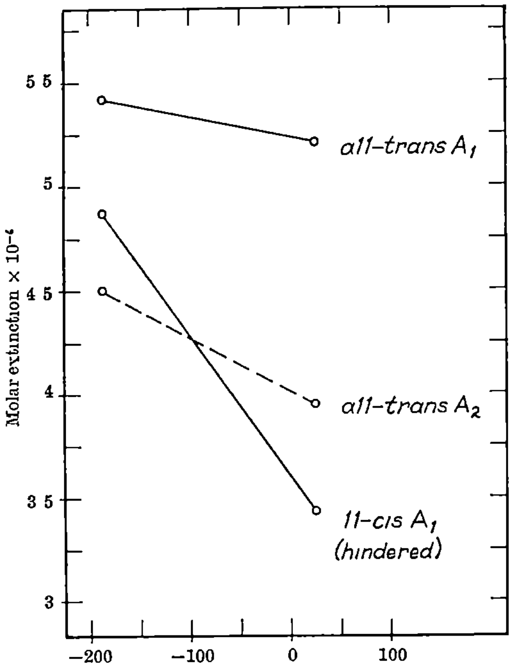


Fig. 10. Effects of cooling on ε_{max} of all-*trans* and 11-*cis* vitamin A and all-*trans* vitamin A_2. Vitamin A_1 fluoresces so intensely in the cold that it appears to absorb less than is actually the case. The change in ε_{max} exhibited by vitamin A_2 is probably more nearly correct for both all-*trans* molecules. The hindered *cis* vitamin A_1 exhibits a much larger change, though here again the change is under-estimated because of strong fluorescence in the cold.

When the all-*trans* isomer is cooled, λ_{max} is displaced about 9.5 mμ toward longer wave-lengths. The absorption band acquires also a degree of symmetry that is lacking at room temperature, shoulders appearing on each side of the maximum, reminiscent of the three-banded structure of the polyene hydrocarbons. The extinction meanwhile rises only about 4 per cent, perhaps owing to the under-correction for fluoresced light already noted. From this point of view some special interest is attached to the behaviour of all-*trans* vitamin A_2, which does not fluoresce strongly; on cooling, its extinction rises 14 per cent (Table 1, Fig. 10).

As with the other polyenes examined, the hindered 11-*cis* isomer of vitamin A exhibits special behaviour. Cooling this isomer shifts λ_{max} only slightly more than in all-*trans* vitamin A_1 or A_2, as was the case with the retinene isomers; but ε_{max} rises 42 per cent, and would probably have risen more if the fluorescence had been adequately controlled. Whereas the extinction of 11-*cis* vitamin A is only 66 per cent of that of the all-*trans* isomer at room temperature, in the cold its extinction rises to 90 per cent of that of the all-*trans* isomer, with simultaneous development of comparable evidences of fine structure, in the form of inflexions lying at both sides of the maximum.

Conclusion. This examination of the absorption spectra of all-*trans* and *cis* isomers of retinene, β-carotene, lycopene and vitamins A and A_2 shows that whereas all-*trans* and unhindered *cis* isomers exhibit parallel behaviour on cooling, sterically hindered *cis* isomers exhibit abnormally large changes of spectrum, including very large increases of extinction, as though cooling had largely or completely relieved the hindrance.

(3) Discussion

By Prof. GEORGE WALD

The unique feature of the carotenoids is that they possess conjugated systems of alternate single and double bonds in linear array. This arrangement not only lends them colour—a property of all extensive conjugated systems—but also the capacity to undergo large changes in shape through *cis–trans* isomerization[14]. In other types of pigment, natural and synthetic, the conjugated systems are mainly bound in rings, and hence held rigidly in position. Exposure to light is one of the most general means for causing *cis–trans* isomerization; and the relatively unrestricted capacity of carotenoids to change their shape in the light is probably the main reason for their special position in animal and plant photoreception[16].

The absorption of light goes with the possession of particularly mobile electrons, associated not with single atoms or bonds, but with the conjugated system as a whole[17]. In valence bond theory this special electronic mobility is embodied in the concept of resonance or mesomerism: the molecule is regarded as a hybrid of all the possible electronic configurations that can be associated with a given constellation of atoms. In molecular orbital theory, the same effect is achieved with the concept of overlapping π-orbitals, occupied by π-electrons which move more or less freely through the entire conjugated system.

Resonance, or the presence of π-electrons (whichever semantic one prefers), lowers the energy required to raise an electron from the ground state to the first excited state, hence poising the absorption at relatively long wave-lengths; and also greatly increases the probability of such transitions, with a consequent intensification of absorption. These are the properties that characterize a pigment.

The spectra considered in the present experiments, except for a passing reference to the *cis*-peak of β-carotene, represent such transitions from the ground to the first electronically excited state. Fine structure, when evident, is caused by superimposed changes of vibrational state (Fig. 12).

The most significant aspects of these spectra are: (1) Their wave-length range, a measure of the energies involved in the electronic transition (Fig. 12), through the relation $\Delta E = Nh\nu = Nhc/\lambda = 2.854 \times 10^7/\lambda$, in which ΔE, the energy of the transition, is expressed in gram calories per mole of quanta, and λ in mμ. (2) The width of spectrum and detail of fine structure. In general, a narrow spectrum and sharp fine structure are signs of the simplification of vibrational changes. Any increase in the variety of such changes, through the overlapping of bands, tends to broaden the spectrum and to wash out detail. (3) The area under the absorption band, when it is plotted on a frequency scale ($\int \varepsilon_\nu d\nu$). This is a measure of the probability of the electronic transition[18]. If the absorption band is reasonably symmetrical and lacks fine structure, the product of ε_{max} and the half-width of the band ($\varepsilon_{max}\ \Delta\nu_{1/2}$) does nearly as well; but these conditions are not usually fulfilled by carotenoid spectra. ε_{max} itself, though frequently involved in theoretical discussions, has little physical meaning, and offers only a rough hint of whether the band area has changed.

For conjugation to be strong, the atoms which compose the conjugated system must lie approximately in a plane It is only then that π-orbitals can overlap or resonance occur[19] Any departure from coplanarity—any twisting of the system—interferes with conjugation to a degree depending upon the angle of twist[20] The result is to depress the probability and usually to increase the energy of the lowest order of electronic transitions, so decreasing the area of the longest wave-length band, and usually shifting it toward shorter wave-lengths

Simple bending of the conjugated chain, even though in a plane, also affects the absorption spectrum Polyenes absorb most strongly when the electric vector of the light is parallel with the long axis of the conjugated chain A polyene in the all-*trans* configuration is linear (except for the regular zigzagging between carbon atoms) and is at its longest extension (Fig 11*a*) In this state its absorption is concentrated in a single electronic transition, and lies at relatively long wave-lengths Any bending of this structure, such as is caused by a *cis* linkage, shortens it, and at the same time opens a new axis of absorption at right angles to the main axis (Fig 11*b*) The result is a decrease in the area, and usually the height, of the main absorption band, and the appearance of a new absorption band (the *cis*-peak), associated with the new absorption vector, lying at shorter wave-lengths than the main band and polarized at right angles to the main band[21]

Mulliken[17a,d] has derived the approximate expression, $\epsilon_{\max} \propto l^2$, in which l is the length from tip to tip of the conjugated system The greatest shortening is caused by a central *cis* linkage, which bends the whole system at an angle of about 120°, shortening it to about 87 per cent (that is, cos 30°) of its all-*trans* length (Fig 11*b*) By Mulliken's formula this should diminish $\epsilon_{\max}$ to 75 per cent of the all-*trans* value The available measurements tend to show somewhat larger decreases of $\epsilon_{\max}$ (compare all-*trans* and 15-*cis* β-carotene in Table 1) Furthermore, a *cis* linkage anywhere in the chain shifts $\lambda_{\max}$ 4–6 mμ toward shorter wave-lengths[14], an effect that is not a necessary consequence of simple bending in a plane Perhaps both departures from expectation are caused by the small twisting that may also be associated with 'unhindered' *cis* linkages (see below) On the other hand, as already noted, such theoretical arguments are properly pursued on the basis, not of $\epsilon_{\max}$, but of the area of the absorption band

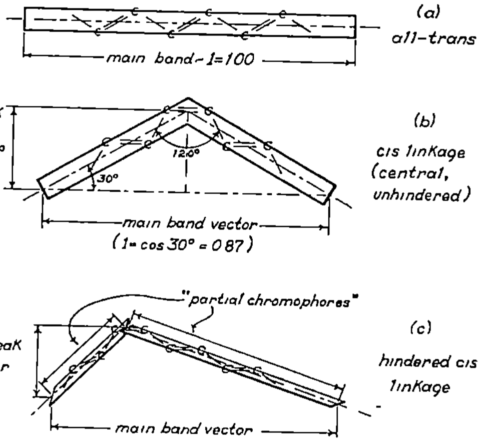


Fig 11 Diagram to show the absorption vectors of such conjugated systems as are present in the carotenoids The conjugated system of an all-*trans* carotenoid is coplanar throughout and at its longest extension An unhindered *cis* linkage bends the molecule, shortening the fundamental vector, and opening a new absorption vector polarized at right angles to this, responsible for the *cis*-peak A hindered *cis* linkage both bends and twists the molecule, resulting in absorptions corresponding not only to the main and *cis*-peak vectors, but to the 'partial chromophores' into which the conjugated system is divided by the break in coplanarity

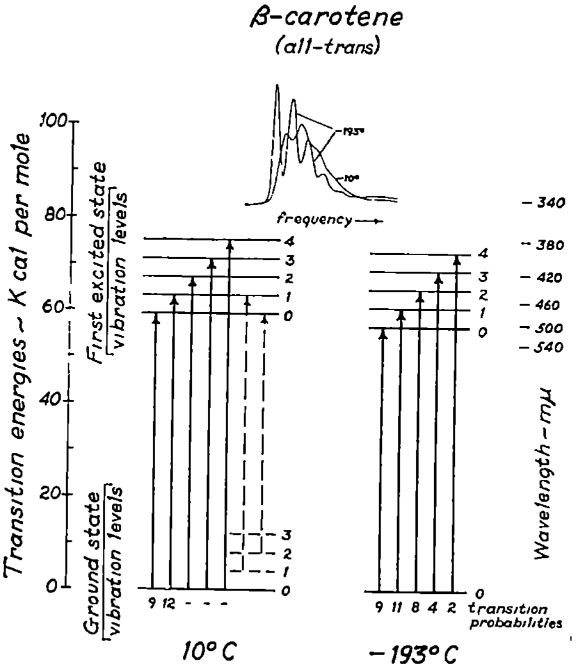

β-carotene
(all-trans)
-193°
-10°
frequency
100
80
60
40
20
0
Transition energies ~ K cal per mole
First excited state vibration levels
Ground state vibration levels
4
3
2
1
0
3
2
1
0
9 12 - - -
10° C
4
3
2
1
0
0
9 11 8 4 2 transition probabilities
-193° C
340
380
420
460
500
540
Wavelength – mμ

Fig 12 Energy diagram of all-*trans* β-carotene, constructed from the data of Fig 7 (left) These results are re-plotted on a frequency scale at the top of the present figure The five maxima that appear in the cold represent transitions from the 0 vibrational level of the ground electronic state to five equally spaced vibrational levels (about 4 k cal apart) of the first electronically excited state The energy of the 0–0 transition is 59 1 k cal per mole in the warm, and 56 5 k cal in the cold In the warm a few transitions go from higher vibrational levels of the ground state, particularly short transitions of this type, shown here with broken lines, are responsible for a long-wave-length tail on the absorption band, which is lost in the cold (This difference does not emerge in the present spectra, though apparent in general) The areas under the successive maxima are an index of the transition probabilities In both warm and cold, the 0–1 transition is most probable Similar energy diagrams, differing only in numerical detail, can be drawn for 15-*cis* and (cold) 11,11′-*dicis* β-carotene, and for lycopene

In a sterically hindered *cis* linkage, the overlap of projecting groups causes a large departure from coplanarity At such a point, as already said, the conjugated system is both bent and twisted (Fig 11*c*) The bend, as always, is associated with a decrease in the fundamental absorption, and the appearance of a *cis*-peak In addition, the twist causes a partial break in conjugation, which to some degree divides the whole system into two shorter segments—'partial chromophores' Associated with the latter are subsidiary bands, lying at shorter wave-lengths than the fundamental band, and overlapping with the *cis*-peak, the main band, or both, depending on the lengths of the segments

It can be concluded that the absorption spectrum offers a variety of indices of molecular structure the linear co-ordinates of the conjugated system, its complexity of vibrational states, whether it lies bent or straight, whether twisted or in a plane With these notes as background, we may discuss the effects of cooling on the absorption spectra

General effects of cooling Cooling resulted in the same general pattern of changes in all our all-*trans* and unhindered *cis* carotenoids Many of these

Table 2. Effects of Cooling on the Areas of Absorption Bands

Carotenoid	Relative area		Ratio of areas (cold/warm)
	Room temperature	– 185° to – 195°	
Unhindered species			
Retinene, all-*trans*	320	317	0.99
9-*cis*	306	313	1.02
β-Carotene, all-*trans*	695	654	0.94
15-*monocis*	494	484	0.98
cis-peak	286	274	0.96
Lycopene, all-*trans*	835	834	1.00
Vitamin A, all-*trans*	293	310	1.06
Vitamin A_2, all-*trans*	324	315	0.97
Hindered species			
Retinene, 11-*cis*	171	241	1.44
Vitamin A, 11-*cis*	193	264	1.37
β-Carotene, 11, 11′-*dicis*	292	529	1.81

Relative areas, in arbitrary units, of the fundamental absorption bands, plotted on a scale of molar extinction versus frequency; that is, $\int \varepsilon \, d\nu$.

changes had been noted earlier in studies of diphenylpolyenes[6]. They include: (1) displacement of the spectrum toward longer wave-lengths; (2) ε_{max} rises, and the absorption band narrows; its area does not change (Table 2); (3) fine structure may appear, or be accentuated; (4) the long-wave length tail of the absorption band is abbreviated, so that usually it cuts off at shorter wave-lengths than in the warm.

These changes have a common basis, which can most readily be understood with reference to such a typical example as all-*trans* β-carotene, the energy diagram of which is shown in Fig. 12. Above the energy diagram are the absorption spectra from which it was derived, the curves of Fig. 7 (left) redrawn on a frequency scale.

The fundamental absorption band of β-carotene, as is apparent in the spectrum measured in the cold, possesses five maxima, representing transitions from the zero vibrational level of the ground electronic state to five vibrational levels of the first electronically excited state. The five absorption maxima are equally spaced, 1,430 cm.$^{-1}$ apart, corresponding to differences in the vibrational energy levels averaging 4.08 k.cal. per mole. The three peaks that appear in the warm clearly correspond to the first three peaks in the cold spectrum, and have almost the same spacing. That is, in both cold and warm, the first five vibrational levels of the first excited state are equally spaced about 4 k.cal. apart.

The absorption peak of lowest frequency measures the energy change corresponding to the 0–0 transition. At room temperature this peak occurs at 20,700 cm.$^{-1}$ ($\Delta E = 59.1$ k.cal.); in the cold it has shifted to 19,780 cm.$^{-1}$ ($\Delta E = 56.5$ k.cal.). That is, cooling the molecule has lowered the energy of the first electronic excitation by 2.6 k.cal., accounting for the displacement of the spectrum towards the red.

Though in the cold the highest extinction appears in the first band (0–0 transition), if the *areas* under the vibration bands are measured, these are seen to be largest in both the cold and warm in the second ('middle') band (0–1 transition). Such areas are an index of the relative probabilities of the various transitions, indicated in Fig. 12 below the energy diagram. The 0–1 transition is most probable at all temperatures.

All these features of the energy diagram, except for small numerical differences, are shared by 15-*cis* and 11,11′-*dicis* β-carotene (cold) and by lycopene.

At room temperature a small fraction of molecules is at higher vibrational levels of the ground state, from which transitions to the upper state involve smaller increments of energy, and hence longer wave-lengths of absorption. A few such transitions are shown in Fig. 12 with broken lines. A scattering of particularly short transitions of this kind accounts for the long wave-length tail on the absorption band in the warm. In the cold, virtually all transitions go from the zero vibrational level of the ground state, and this tail is lost. (Our measurements on β-carotene do not show this difference, though I think that more detailed measurements would have revealed it. It is apparent in many of our other spectra.)

Why do all polyene spectra that have been examined rise in extinction, that is, sharpen in structure, and shift toward the red on cooling? The shift towards the red, as just said, is an expression of the lowering of the transition energy between the ground and first excited state. It may be supposed that in the warm, molecular motions, in part the result of collisions, bend and twist the conjugated system from moment to moment so as to produce effects that resemble statistically those of *cis* linkages, hindered and unhindered. In the cold and in a rigid solvent, the molecule is subjected to less deformation, and can maintain relatively undisturbed its most extended and planar conformation. Such a view raises no serious energetic difficulties, for the mean thermal kinetic energy at room temperature is about 0.9 k.cal. per mole (3/2 RT), which is of about the right magnitude to produce the minor bendings and interruptions of conjugation that would account for the displacement of spectrum toward shorter wave-lengths and the fall of extinction and broadening that we observe in the warm. The effects of warming can mimic those of a *cis* linkage only qualitatively; for an actual *cis* linkage is fixed in position in all molecules of one species, whereas warming causes transient and fluctuating effects, different in all members of the molecular population.

It seems to me that this hypothesis involves several theoretical consequences that should be mentioned, though they do not emerge in the present measurements. If it is true that the molecule achieves more perfect conjugation in the cold than in the warm, this should result in an increased resonance energy, and a consequent lowering of the ground state as well as the first excited state. Furthermore, one should expect the area of the absorption band to be larger in the cold than in the warm, just as it is larger in the all-*trans* than in *cis* configurations; as Table 2 shows, within the accuracy of the present measurements, the areas are the same at room temperature and in the cold. Finally, I think one should expect to find higher absorption in the warm in the ultra-violet, owing to contributions from new absorption vectors and partial chromophores. Perhaps more detailed investigation will uncover all these effects.

Cooling and steric hindrance. It was shown above that sterically hindered *cis* carotenoids exhibit abnormally large changes of spectrum on cooling, as though lowering the temperature had relieved the hindrance. ε_{max} rises, and λ_{max} shifts toward the red, so as to approach the properties of an unhindered *cis* molecule.

More significant than either of these effects is the behaviour of the *area* of the absorption band. As shown in Table 2, though the areas of the main absorption bands of all-*trans* and unhindered *cis* carotenoids are approximately the same in the warm and cold, those of 11-*cis* retinene and vitamin A

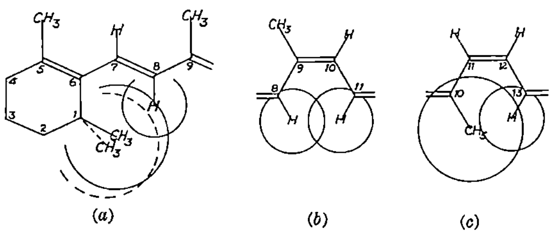


Fig. 13. Three sources of intramolecular steric hindrance encountered in carotenoids. (a) Hindrance between methyl groups on a β-ionone ring and a hydrogen atom on the side-chain. What is believed to be the prevalent s-*trans* orientation is shown here. (b) Hindrance between H atoms at an 'unhindered' *cis* linkage. It is only when H is given a van der Waals radius of 1.2 A. that the overlap shown here occurs. At a radius of 0.85 A. or less there would be no hindrance. (c) Hindrance between a methyl group and H at a hindered *cis* linkage. Only this last type of hindrance appears to be appreciably relieved by cooling

increase about 40 per cent, and that of 11,11′-*dicis* β-carotene increases just twice as much, about 80 per cent, on cooling to liquid-nitrogen temperature.

Such molecules present three sources of steric hindrance (Fig. 13): (*a*) overlap between the methyl groups on C_1 of the ring and the H atom on C_8, causing a twist between the ring and side-chain[22]; (*b*) overlap between H atoms at an 'unhindered' *cis* linkage. This is small, if it exists at all, yet is sometimes held responsible for the small shifts of spectrum toward shorter wave-lengths and some of the decrease of extinction that characterize such linkages[14]; (*c*) overlap of an H atom with a methyl group at such linkages as 11-*cis*.

Of these three types of hindrance, only one appears to be relieved by cooling. (*a*) Cooling does not change appreciably the hindrance between ring and side chain, as shown by the fact that it has parallel effects on β-carotene, which possesses two ionone rings, and lycopene, which has none (Tables 1 and 2). (*b*) Cooling does not relieve whatever overlap of H atoms may exist at 'unhindered' *cis* linkages, as shown by the fact that it has parallel effects on unhindered *cis* and all-*trans* carotenoids. (*c*) It can be concluded that cooling relieves specifically the steric hindrance at such linkages as 11-*cis*.

What is the mechanism of this effect? The geometry of molecules involves two kinds of dimension: the distances between bonded atoms, expressed in the bond radii, and the distances at which non-bonded atoms and groups begin to repel one another, expressed in the van der Waals radii. Instances of intramolecular steric hindrance seem as though they should involve van der Waals radii. These are generally estimated to be about 0.8 A. larger than the bond radii[23]. Yet estimates of intramolecular over-crowding made on this basis tend to predict larger effects than are observed; and values smaller than the van der Waals radii, perhaps at times approaching the bond radii, may be more applicable (cf. ref. 24).

I would suppose that the repulsion radius is made up not only of the space occupied by atomic structures, but includes also to a degree the space swept out by atoms and groups in their thermal stretching, bending and twisting motions. In this sense the close approach of such groups must give rise to a soft rather than a hard hindrance. It is equivalent, not to the contact between rigid surfaces, but rather to a fluctuating interpenetration of 'Lebensraume', that involves considerable 'give'.

I would suppose that lowering the temperature, by quieting down the thermal stretching, bending and twisting motions of attached groups, effectively contracts their van der Waals radii. This is the same type of effect that we have already invoked with regard to the conjugated chain. It is this effect that I think is primarily responsible for the relief of steric hindrance on cooling.

Why are hindrances of types (*a*) and (*b*) in Fig. 13 not relieved by cooling?

The hindrance between the ring and side-chain is probably considerably 'harder' than at an 11-*cis* linkage, because, in the s-*trans* configuration shown in Fig. 13, *two* methyl groups are in conflict with an H atom; and the ring holds these methyl groups more rigidly than would a straight chain[25].

The assumed hindrance between H atoms at an 'unhindered' *cis* linkage requires further consideration. Such hindrance exists if hydrogen is assigned the full van der Waals radius of 1.2 A.; but this value is probably too large to be applicable in the present instance. Braude has suggested that the onset of spectrally detectable effects owing to steric hindrance coincides better with a van der Waals radius of about 0.6 A. for hydrogen[24]; even if one expanded this to 0.8–0.9 A., no conflict would exist at an unhindered *cis* linkage, and the problem of relieving it by cold or otherwise would not arise. On the other hand, if this is a source of hindrance, one would not expect it to be relieved appreciably by cooling; for the stretching and bending energies of bonded hydrogen atoms are so large as scarcely to be activated even at room temperature[26].

For this reason also the relief of hindrance on cooling at such a linkage as 11-*cis* cannot appreciably involve the H atom, and must be ascribed almost entirely to the contraction of the effective van der Waals radius of the methyl group.

Implications and consequences. The assumption that the effective van der Waals radii contract considerably at low temperatures can be tested further, and made quantitative with the help of these and other kinds of measurement. In particular, X-ray crystallography at low temperatures should yield valuable information concerning the variation of van der Waals radii with temperature, and whatever molecular distortions accompany such changes. (I understand that such measurements have been made by W. N. Lipscomb at Minnesota and by Fankuchen at Brooklyn Polytechnic Institute, both of whom inform me in personal communications that cooling seems to have only very small effects on bond radii, and should have its principal effects on the distances of intermolecular and intramolecular contact.)

One interesting result of our observations is that, in the two instances in which measurements were made at intermediate temperatures (Fig. 5), ε_{max} rose linearly as the temperature was lowered, though in the case of 11-*cis* retinene an abrupt change in slope occurred at about – 100°, the reason for which is not known. The solvent is still highly fluid at this temperature, and continues so until below – 150°.

The temperature at which our measurements stopped was arbitrarily that of liquid nitrogen. At this temperature, as already noted, 11-*cis* retinene has achieved as high an ε_{max} as an unhindered *mono-cis* isomer. That is, it behaves as though its steric hindrance were entirely relieved; and judging from Figs. 8 and 10, this must be nearly the case also with 11,11′-*dicis* β-carotene and 11-*cis* vitamin A. Once the hindrance is gone, one should expect any further rise of ε_{max} with lowering of the temperature to have the same slope in all these molecules

The only data adequate to bear upon this point are those involving 11-*cis* retinene in Fig 5, and here there is no indication that this expectation will be realized The slope of the function would have to break very sharply to a lower value at temperatures just below that of liquid nitrogen, for $\varepsilon_{max.}$ of the hindered *cis* molecule not to rise rapidly *above* that of unhindered *cis* forms, a phenomenon we would be hard put to explain

From this point of view the band areas shown in Table 2 are more reassuring At − 190°, 11-*cis* retinene has a band area still only 0 77 as great as that of 9-*cis* retinene 11,11′-*dicis* β-carotene has a band area higher than that of 15-*monocis* carotene, as it should, since two *cis* linkages tend to compensate each other, bending the molecule less, and usually for this reason depressing the extinction less than one central *cis* linkage[14] Perhaps, therefore, as in other aspects of this problem, the argument encounters difficulties in terms of ε_{max} that are avoided when one considers instead the band area

The observation that steric hindrance is partly or wholly relieved at low temperatures has a curious consequence The twisting of the molecule occasioned by steric hindrance may, if sufficiently large, cause observable optical activity, depending upon whether the twist is to the right or the left In all but highly hindered molecules, since, as noted, such hindrances are 'soft', racemization occurs rapidly at room temperature, and ordinarily the single optical isomers cannot be isolated In several instances of large hindrance, however, racemates have been resolved, and the enantiomorphs are relatively stable[25,27] Our observations suggest that cooling such a single optical isomer, by decreasing the hindrance, might remove the barrier to racemization We should then observe the strange phenomenon of a chemical reaction, a racemization, activated by lowering the temperature This possibility should certainly be examined

Changes of absorption spectrum similar to those we have observed on cooling carotenoids in solution are observed in the warm when these and other pigments are embedded in solid or quasicrystalline structures So, for example, spectra of the visual pigments—all of which are retinene-proteins—exhibit a displacement of λ_{max} several mμ toward the red, and rise of extinction, when measured in the retina or in suspensions of whole or fragmented outer segments of rods[28] The latter are quasi-crystalline structures, in the sense that many of their molecules, including the visual pigments themselves, are oriented relative to one another[29] The same relations involve the spectra of the chlorophylls measured in cells or chloroplast suspensions, compared with their spectra in solution[30] In all these cases the spectrum in cell particles appears to differ from that measured in solution in much the same way that spectra at low temperatures in rigid solvents differ from those at room temperature Perhaps in solid structures, as in the cold, the quieting of thermal motions and relief from collision permit these pigments to maintain a less disturbed condition of linearity and coplanarity, with the consequent increase of target length and improvement of conjugation that yield the observed spectral changes

These investigations were supported in part by grants from the Rockefeller Foundation and the U S. Office of Naval Research We are indebted to Dr. H H Inhoffen for a gift of 15,15′-*cis* β-carotene, to Dr O. Isler for gifts of 11,11′-*dicis* β-carotene and vitamin A_2 acetate; to Prof L Zechmeister for lycopene; to Dr. W. Oroshnik for 11-*cis* vitamin A and retinene, and to the Organic Research Laboratory of Distillation Products Industries, Rochester, New York, for supplies of 9-*cis*, 13-*cis* and 9,13-*dicis* retinene

(Dr Jurkowitz—now at the University of Chicago Clinics—performed these experiments in the summer of 1955, following his first year at medical school Mr Loeb, now a third-year student at Harvard Medical School, was an undergraduate at the time of these experiments (1956–57))

[1] Hall, D M, and Turner, E. E, *J Chem Soc*, 1242 (1955)

[2] Lewis, G. N, and Lipkin, D, *J Amer Chem Soc*, **64**, 2801 (1942)

[3] (*a*) Hubbard, R, Gregerman, R I, and Wald, G, *J Gen Physiol*, **36**, 415 (1952–53) (*b*) Robeson, C D, Blum, W P, Dieterle, J M, Cawley, J D, and Baxter, J G, *J Amer Chem Soc*, **77** 4120 (1955)

[4] (*a*) Oroshnik, W, *J Amer Chem Soc*, **78**, 2651 (1956) (*b*) Oroshnik, W, Brown, P K, Hubbard, R, and Wald, G, *Proc U S Nat Acad Sci*, **42**, 578 (1956)

[5] (*a*) Hubbard, R, and Wald, G, *J Gen Physiol*, **36**, 269 (1952–53) (*b*) Wald, G, in "Enzymes, Units of Biological Structure and Function", O H Gaebler, ed, 355 (Academic Press, New York, 1956) *Exp Cell Res*, Supp, **5**, 389 (1958)

[6] Hausser, K W, Kuhn, R, and Seitz, G, *Z physikal Chemie*, **29**, 391 (1935)

[7] Oroshnik, W, and Mebane, A D, *J Amer Chem Soc*, **76**, 5719 (1954)

[8] Hubbard, R, *J Amer Chem Soc*, **78**, 4662 (1956)

[9] Zimmerman, G, Chow, L, and Paik, U, *J Amer Chem Soc*, **80** 3528 (1958)

[10] Brown P K, and Wald, G, *J Biol Chem*, **222**, 865 (1956)

[11] Livingston, R *J Amer Chem Soc*, **77**, 2179 (1955)

[12] Porret, D. and Rabinowitch, E, *Nature*, **140**, 321 (1937)

[13] Inhoffen, H H, Bohlmann, F, Bartram, K, Rummert, G, Pommer H, Westphal, F, and Linhoff, G, *Ann Chemie*, **570**, 54 (1950)

[14] Zechmeister, L., *Chem Rev*, **34**, 267 (1944)

[15] Isler, O, Chopard-dit-Jean, L H, Montavon, M, Rüegg, R, and Zeller, P, *Helv Chim Acta*, **40**, 1256 (1957) This isomer was first described by Eugster, C H, Garbers, C F, and Karrer, P, *Helv Chim Acta*, **36**, 1378 (1953)

[16] Wald, G, *Vitamins and Hormones*, **1**, 195 (1943), "Harvey Lectures", **41**, 117 (1945–46)

[17] General theoretical discussions of these matters will be found in (*a*) Mulliken, R S, *J Chem Phys*, **7**, 121, 364 (1939) (*b*) Lewis, G N, and Calvin, M, *Chem Rev*, **25**, 273 (1939) (*c*) Pauling, L, "Nature of the Chemical Bond" (Cornell Univ Press, 1948) (*d*) Braude, E A, and Waight, E S, in "Progress in Stereochemistry", **1**, 126 (1954) (*e*) Platt, J R, in "Radiation Biology", **3**, 71, A Hollaender, ed (McGraw-Hill Book Co, New York, 1956)

[18] Fowler, R H, "Statistical Mechanics", 722 (Cambridge Univ Press, 1936) Rollefson, G K, and Burton, M, "Photochemistry", 38 (Prentice-Hall, New York, 1939)

[19] Pauling, L, "Nature of the Chemical Bond", 217 (Cornell Univ Press, 1948)

[20] Dewar, M J S, in "Steric Effects in Conjugated Systems", 46 (Academic Press, New York, 1958)

[21] Zechmeister, L, le Rosen, A L, Schroeder, W A, Polgár, A, and Pauling, L, *J Amer Chem Soc*, **65**, 1940 (1943)

[22] Oroshnik, W, Karmas, G, and Mebane, A L, *J Amer Chem Soc*, **74**, 295 (1952) Cf also Braude and Waight, in "Progress in Stereochemistry"

[23] Pauling, L, "Nature of the Chemical Bond", 187 (Cornell Univ Press, 1948).

[24] Braude, E A, and Waight, E S, in "Progress in Stereochemistry", **1**, 146 (1954)

[25] Compare the discussion of 'buttressing' effects in the racemization of sterically hindered biphenyls in Rieger, M, and Westheimer, F H, *J Amer Chem Soc*, **72**, 19 (1950)

[26] Herzberg, G, "Infrared and Raman Spectra of Polyatomic Molecules", 192 (Van Nostrand, New York, 1945)

[27] An extensive review of this field to 1943 is found in the article by Shriner, R L, Adams, R and Marvel, C S, in "Organic Chemestry", H Gilman, ed, **1**, 343 (John Wiley and Sons, New York, 1943) See also Westheimer, F H, and Mayer, J E, *J Chem Phys*, **14**, 733 (1946) Westheimer, F H, *ibid*, **15**, 252 (1947) Newman, M S, and Hussey, A S, *J Amer Chem Soc*, **69**, 3023 (1947)

[28] Wald, G, and Brown, P K, *Science*, **127**, 222 (1958) Denton, E J, in "Visual Problems of Colour", Symp No 8, National Phys Lab U K, 175 (H M Stationery Office, London, 1958) Sidman R L, *Ann N Y Acad Sci*, **74**, 182 (1958)

[29] Schmidt, W J, *Kolloid-Zeitschr*, **85**, 137 (1938) Sjostrand, F. S, *Erg Biol*, **21**, 128 (1958) Denton, E J, *Proc Roy Soc*, B, **150**, 78 (1959)

[30] Smith, E L, *J Gen Physiol*, **24**, 565 (1940–41) Also extensive reviews by Rabinowitch, E I, "Photosynthesis", **2**, pt 2, 1841 (Interscience Pub, New York, 1956), and French, C S, and Young, V M K, in "Radiation Biology", **3**, 343 (A Hollaender, ed) (McGraw-Hill, New York, 1956)

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 19

Illuminating Engineering Society (at Caxton Hall, Caxton Street, London, S W 1), at 6 p m —Mr L J Davies "The Generation of Light" (Golden Jubilee Lecture)

University of London (at Birkbeck College, Malet Street, London, W C 1), at 6 p m —Prof E G Boring (Harvard University) "The Psychology of the History of Science" (First of three lectures on "The Pattern of Modern Psychology")*

British Association for the Advancement of Science in association with Granada TV Network (at the Guildhall, London, E C 2), at 8 30 p m —Dr Edward R Murrow Second of the Inaugural Series of the Granada Lectures on the theme of "Communication in the Modern World"

Royal Geographical Society (at 1 Kensington Gore, London, S W 7), at 8 30 p m —Sir Charles Darwin, F R S "Darwin the Traveller"

Tuesday, October 20

University College (in the Anatomy Theatre, Gower Street, London, W C 1), at 1 15 p m —Dr A W Stonier "The Differences between English and American Universities" *

Royal Institute of Chemistry (joint meeting with the South East Essex Technical College Scientific Society, at the South East Technical College, Longbridge Road, Dagenham, Essex), at 7 p m —Mr D G Chisman "The Education and Training of Chemists"

Wednesday, October 21

Institution of Chemical Engineers (at the Geological Society, Burlington House, Piccadilly, London, W 1), at 5 30 p m —Mr K P Lanneau "Gas-solids Contacting in Fluidized Beds"

Institution of Mechanical Engineers, Steam Group (at 1 Birdcage Walk, Westminster, London, S W 1), at 6 p m —Mr P Hamer "Present-day Feed-water Treatment for High-Pressure Boilers"

Royal Institute of Chemistry, London Section (at King's College, Strand, London, W C 2), at 6 30 p m —Dr D D Davies "Recent Advances in Plant Biochemistry"

Thursday, October 22

University College (in the Anatomy Theatre, Gower Street, London, W C 1), at 1 15 p m —Prof L S Penrose, F R S "Human Chromosomes" *

Physical Society, Optical Group (in the Science Museum Lecture Theatre, South Kensington, London, S W 7), at 2 p m —Discussion on the Stockholm Conference

University College (in the Eugenics Theatre, Gower Street, London, W C 1), at 5 p m —Dr B Cheng "Some Aspects of Space Law" *

Royal Society of Medicine, Experimental Medicine and Therapeutics Section (at 1 Wimpole Street, London, W 1), at 5 30 p m —Prof Sir Hans Krebs "Biochemical Aspects of Ketosis" (W E Dixon Memorial Lecture)

Illuminating Engineering Society (at the Institution of Civil Engineers, Great George Street, London, S W 1) at 6 p m —Dr W H Glanville, F R S "Light and Road Safety" (Golden Jubilee Lecture)

Institution of Mechanical Engineers, Hydraulics Group (at 1 Birdcage Walk, Westminster, London, S W 1), at 6 p m —Discussion on "Effect of Cavitation in Hydraulic Machinery"

University of London (at Birkbeck College, Malet Street, London, W C 1), at 6 p m —Prof E G Boring (Harvard University) "The Genesis of Modern Psychology" (Second of three lectures on "The Pattern of Modern Psychology")*

Society of Chemical Industry (at the Royal Institution, 21 Albemarle Street, London, W 1), at 6 30 p m —Prof H Mark (U S A) 'Recent Progress in Polymer Chemistry" (Baekeland Memorial Lecture)

Oil and Colour Chemists' Association, London Section (joint meeting with the Oils and Fats Group of the Society of Chemical Industry, at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W 1), at 7 p m —Dr W C Ault (Philadelphia) "Polymers and Plasticisers Derived from Fats"

Friday, October 23

Royal Institution (at 21 Albemarle Street, London, W 1), at 9 p m —Sir Norman Kipping "How Can We Help Underdeveloped Countries ?

Saturday, October 24

British Psychological Society (in the Gustav Tuck Theatre University College, Gower Street, London, W C 1), at 2 35 p m —Prof Edwin G Boring "The Role of the Zeitgeist in the History of Perception"

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned

Research Assistant (with a special interest in electronics or fluid mechanics) for work in the Hydraulics Laboratory—The Professor of Civil Engineering, The Queen's University, Belfast (October 31)

Research Fellow in Physical Chemistry, for work involving the study of solids by physical methods including mass spectroscopy and positive ion bombardment—The Deputy Registrar, The University, Edgbaston, Birmingham 15 (October 31)

Senior Lecturer in Electrical Engineering at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, October 31)

Senior Lecturer (with a special interest in ecology, plant physiology or genetics) in Agricultural Botany in the Department of Plant Science, Canterbury Agricultural College, University of New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (New Zealand, October 31)

Analyst (with a good honours degree in chemistry or its equivalent, and prepared to specialize in the analysis of rocks and minerals) in the Geology Department—The Professor of Geology, King's College, University of London, Strand, London, W C 2 (November 1)

Lecturer or Assistant Lecturer in the Department of Pharmacology—The Registrar, The University, Leeds 2 (November 4)

Lecturer in Physics, to undertake research in the field of metal physics or solid state physics (low temperature facilities are available) —Prof P M S Blackett, F R S , Physics Department, Imperial College of Science and Technology, London, S W 7 (November 9)

Lecturer in the Department of Physiology in the Faculty of Medicine, University College, Ibadan, Nigeria—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W C 1 (November 9)

Chair of Geology in the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W C 1 (November 10)

Lecturer in Psychology at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, November 14)

Chair of Philosophy and Headship of the Department—The Registrar, The University, Nottingham (November 30)

Chair of Geography in the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (New Zealand, December 15)

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

International Wool Secretariat British Sheep Breeds Wall Sheets Set of 12 sheets, 6*s* (post free) (Size 18½ in × 13 in) (London International Wool Secretariat, 1959) [107

Educational Productions, Ltd Filmstrip No 5260 Insects in the Garden 28 frames Notes for use with Filmstrip No 5260 Pp 10 (East Ardsley, Wakefield Educational Productions, Ltd , 1959) 16*s* 6*d* [107

Ciba (A R L), Limited Technical Notes, No 198 (June 1959) Bonding in the Fairchild F-27 Pp 6 (Duxford Ciba (A R L), Ltd , 1959) [147

Educational Productions, Ltd Filmstrip No CX 6290 Seed Germination 23 frames 27*s* 6*d* Notes for use with Filmstrip No CX 6290 Pp 8 Filmstrip No CX 6332 Grasses 27 frames 27*s* 6*d* Notes for use with Filmstrip No CX 6332 Pp 13 (East Ardsley, Wakefield Educational Productions, Ltd , 1959) [147

Colonial Office Fishery Publications No 12 The Hydrography of the British East African Coastal Waters, Part 2 By B S Newell Pp iii+18 (London H M Stationery Office, 1959) 5*s* 6*d* net [147

National Institute of Agricultural Botany Herbage Seed Growers Leaflet No 4 Harvesting and Threshing Grass and Clover Seed Pp 17 (Cambridge National Institute of Agricultural Botany 1959) [177

British Steel Castings Research Association Sixth Annual Report, 1959 Pp 28 (Sheffield British Steel Castings Research Association, 1959) [227

Education for the Age of Science Statement by President Eisenhower's Science Advisory Committee, 24 May, 1959 Pp 47 (London United States Information Service, 1959) [227

Department of Scientific and Industrial Research and Fire Offices' Committee Fire Research 1958 Report of the Fire Research Board with the Report of the Director of Fire Research Pp vi+54+8 plates (London H M Stationery Office, 1959) 5*s* net [237

United Kingdom Atomic Energy Authority Fifth Annual Report for the period 1st April, 1958—31st March, 1959 Pp vii+68+4 plates (London H M Stationery Office, 1959) 5*s* net [237

English Version of the Remarks to the Second Edition of the General Catalogue of Variable Stars Pp 74 (Herstmonceux International Astronomical Union, Royal Greenwich Observatory, 1959) [247

Other Countries

The Indian Ephemeris and Nautical Almanac for the year 1960. Pp xxviii+444 (Delhi Manager of Publications, 1959) Rs 14 00 22*s* [107

United States Department of the Interior Fish and Wildlife Service Fishery Bulletin No 146 Decline of the Yellowtail Flounder (*Limanda ferruginea*) Off New England By William F Royce, Raymond J Buller and Ernest D Premetz Pp iv+169–267 (Washington, D C Government Printing Office, 1959) 55 cents [107

Pennsylvania State University Mass Transfer Between Phases By Prof Thomas K Sherwood (Thirty-third Annual Priestley Lectures) Pp xi+86 (University Park, Pennsylvania Pennsylvania State University, 1959) [107

Continuity and Number By B Goussinsky Pp 31 (Tel Aviv B Goussinsky, 5 Rosenbaum Street, 1959) 0 50 dollars [107

Annals of the New York Academy of Sciences Vol 72, Article 14 The Influence of Hormones on Lipid Metabolism in Relation to Arteriosclerosis By Abraham Dury, Carleton R Treadwell and 35 other authors Pp 787–1054 (New York New York Academy of Sciences, 1959) 4 dollars [107

Report of the FAO/UNICEF Regional School Feeding Seminar for Asia and the Far East, Tokyo, Japan, 10–19 November 1958 (FAO Nutrition Meetings Reports Series, No 22) Pp v+52 (Rome Food and Agriculture Organization of the United Nations, London H M Stationery Office, 1959) 2*s* 6*d* [107

International Council of Scientific Unions Financial Statement for the period from 1 November 1957 to 31 December 1958 Pp 12 (The Hague International Council of Scientific Unions, 1949) [107

British Honduras Annual Report of the Forest Department for the year 1957 Pp 24 (Belize Forest Department, 1959) [107

Arbeitsgemeinschaft für Forschung des Landes Nordrhein-Westfalen, Heft 82 Periodisch Wiederholte Zündungen durch Stosswellen Von Paul Schmidt Pp 57 (Koln und Opladen Westdeutscher Verlag, 1959) 5 20 D M [147

Annals of the New York Academy of Sciences Vol 77, Article 3 Hematopoietic Mechanisms By Albert S Gordon, Walter S Root and 65 other authors Pp 407–820 5 dollars Vol 78, Article 2 The Biology of the Amoeba By Henry I Hirshfield and 22 other authors Pp 401–704 4 50 dollars (New York New York Academy of Sciences, 1959) [147

Consejo Superior de Investigaciones Publicaciones del Instituto de Quimica "Alonso Barba", Vol XII, Año 1958 (Colleccion de los Trabajos Publicados durante dicho ano en los Anales de la Real Socieded Española de Fisica y Quimica) Pp ii+354 (Madrid Instituto de Quimica "Alonso Barba", 1959) [147

Trace Element Problems in Nature a Symposium held in the Botany Department, University of Cape Town, May, 1958 Pp iv+55 (Cape Town University of Cape Town, Department of Botany, 1959) [147

United States Department of Commerce Weather Bureau Forecasting Guide No 3 Hurricane Forecasting By Staff Members U S Weather Bureau Pp v+108 (Washington, D C U S Department of Commerce, Weather Bureau, 1959) [147

National Academy of Sciences—National Research Council 1957–1958 Pp iv+65 (Washington, D C National Academy of Sciences —National Research Council, 1959) [147

Smithsonian Miscellaneous Collections, Vol 138, No 1 Pueblo del Arroyo, Chaco Canyon, New Mexico By Neil M Judd Pp vii+222+55 plates (Publication 4346) (Washington, D C Smithsonian Institution, 1959) [147

Deutsches Hydrographisches Institut, Hamburg Jahresbericht Nr 13 fur das Jahr 1958 Pp 81 (Hamburg Deutsches Hydrographisches Institut, 1959) [167

New Zealand Air Department New Zealand Meteorological Service Meteorological Investigations for 1956 Pp i+87 (Wellington Government Printer, 1959) [177

Centro Brasileiro de Pesquisas Fisicas Notas de Fisica Vol 4, No 18 A Stochastic Theory of Chromatography By H Macedo, A L Zamith and J Danon Pp 15 Vol 4, No 21 Sidereal Anisotropy of High Energy Cosmic Rays near the Equator By I Escobar, N Nerurkar and R Weil Pp 12 Vol 4, No 22 The Disintegration of Ga^{73} By J Goldemberg, L Marquez, E W Cybulska, N L Costa, and I G Alkeida Pp 7 Vol 4, No 23 Effect of Non-Locality in Fermi Interactions Due to Vector Mesons on the Decays $\Sigma \rightarrow p + \gamma$ and $\mu \rightarrow e + \nu + \bar{\nu}$ By Prem Prakash and A H Zimerman Pp 11 Vol 4, No 24 Hyperfragments Produced by K° Mesons from K^{+} Charge Exchange By M Baldo Ceolin, H Huzita, S Natali, U Camerini, and W F Fry Pp 9 Vol 4, No 25 On the Masses of Elementary Particles By Abdus Salam and J Tiomo Pp 4 Vol 4, No 26 The Poles of the S-Matrix of a Rectangular Potential Well or Barrier By H M Nussenzveig Pp 36 Vol 5, No 1 The Decay of TI^{44} By E W Cybulska and L Marquez Pp 9 Vol 5, No 2 Correlated Polarization of Muons in $K\mu 3$–Decay By S W Macdowell Pp 6 Vol 5, No 3 On the Analytic Properties of Partial Amplitudes By S W Macdowell Pp 18 Vol 5, No 4 The Attractive K^{-}-Meson Proton Interaction By Erasmo M Ferreira Pp 3 Vol 5, No 5 On Anomalous Magnetic Moment of Nucleons By Colber G de Oliveira Pp 13 Vol 5, No 6 Determination of the Stability Constants of Thorium Nitrate Complexes with Anion-Exchange Resins By J Danon Pp 14 Vol 5, No 7 Paper Chromatography of Inorganic Ions in Nitrate Media 1 Scandium, Yttrium, Actinum and the Lanthanides By J Danon and M C Levi Pp 4 (Rio de Janeiro Centro Brasileiro de Pesquisas Fisicas, 1959) [177

Cytophotometry by Silver Analysis of Photomicrographs Description of a New Method and Its Application to the Study of Corpuscular Haemoglobin By Mikko Niemi (*Acta Anatomica*, Supplementum 34–2 ad Vol 35, 1958) Pp 92 (Basel and New York S Karger, 1958) 13 20 Swiss francs [207

Canada Department of Mines and Technical Surveys Geological Survey of Canada Bulletin 48 Contributions to Canadian Palaeontology Fungal Filaments in a Devonian Limestone from Alberta By Wayne L Fry and D J McLaren Petrified Logs of *Cupressinoxylon* from the West Shore of Chilko Lake, British Columbia By Wayne L Fry A Revision of the Devonian Coral Genus *Synaptophyllum* Simpson By D J McLaren Pp vi+33+10 plates 1 dollar Bulletin 49 Marine Jurassic Rocks in Nelson and Salmo Areas, Southern British Columbia By Hans Frebold Pp vii+20+5 plates 1 dollar (Ottawa Queen's Printer, 1959) [207

Publications of the Kapteyn Astronomical Laboratory, University of Groningen No 60 Reduction to the FK3 System for the Photographic Proper Motions in the Selected Areas at Declination 0° published in Groningen Publications No 56 By L Plaut Pp iii+42 (Groningen The University, 1959) [207

Centre National de la Recherche Scientifique, Paris Publications de l'Observatoire de Haute-Provence Vol 4, No 15 Sur l'Emmission des Raies H et K du Calcium Ionisé dans le Spectre du Ciel Crépusculaire Par M Dufay Pp 1 Vol 4, No 19 Comètes—Polarisation de la Comète *Mrkos* (1957*d*) Note de Mme Marie-Thérèse Martel, présentée par M André Danjon Pp 3 Vol 4, No 20 Polarisation de la Nébuleuse du Crabe, Polarisation et Couleur des Nébuleuses Diffusantes Par Marie-Therese Martel Pp 82 Vol 4, No 21 l'Activité Aurorale aux Basses Latitudes Par Daniel Barbier Pp 22 Vol 4, No 22 Physique de l'Atmosphere—Absorption Atmosphérique dans le Proche Infrarouge Note de Mme Madeleine Lunel, présentée par M André Danjon Pp 4 Vol 4, No 23 The Sodium Twilight Airglow 1955–1957 Par J E Blamont, T M Donahue, V R Stull, and W Weber Pp 52 Vol 4, No 24 Astrophysique—Évolution du Spectre de Nova *R S Ophiuchi* du 14 au 25 Juillet 1958 Note de Mlle Marie Bloch et M Jean Dufay, transmise par M André Danjon Pp 4 (Paris Centre National de la Recherche Scientifique, 1958 et 1959) [217

Annals of the New York Academy of Sciences, Vol 79, Article 2 Studies on Marine Bryozoa XI Antarctic Osthimosiae By Mary D Rogick Pp 9–42 (New York New York Academy of Sciences, 1959) 1 50 dollars [227

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Bulletin of the American Museum of Natural History Vol 118, Article 1 Results of the Archbold Expeditions No 79—Summary of the Fifth Archbold Expedition to New Guinea (1956–1957) By L J Brass Pp 1–70+plates 1–8 (New York American Museum of Natural History, 1959) 1 50 dollars [237

Smithsonian Miscellaneous Collections Vol 139, No 2 The Birds of Isla Escudo de Veraguas, Panama By Alexander Wetmore Pp 27+1 plate (Publication 4378) Vol 139, No 4 A Review of the Genus *Hoplomys* (Thick-Spined Rats), with description of a New Form from Isla Escudo de Veraguas, Panama By Charles O Handley, Jr Pp 10 (Publication 4380) (Washington, D C Smithsonian Institution, 1959) [247

Université de Paris Travaux et Mémoires de l'Institut d'Ethnologie, No 62 Requila—un Village Nahuatl de Mexique Oriental Par Dr Georgette Soustelle Pp x+266+15 planches (Paris Institut d'Ethnologie, Université de Paris, 1959) [247

United States Department of the Interior Geological Survey Bulletin 1028–J Geologic Reconnaissance of Gareloi Islands, Alaska By Robert R Coats Pp v+249–256+plates 33–35 Bulletin 1028–K Geology of Segula, Davidof and Khvostof Islands, Alaska By W H Nelson Pp v+257–266+plates 36–38 Water-Supply Paper 1461 Geology, Hydrology, and Chemical Character of Ground Waters in the Torrance-Santa Monica Area, California By J F Poland, A A Garrett and Allen Sinnott Pp xi+423+20 plates Water-Supply Paper 1465 Quality of Surface Waters for Irrigation, Western United States, 1955 Prepared under the direction of S K Love Pp viii+189+1 plate Water-Supply Paper 1474 Geology and Ground-Water Resources of the Big Blue River above Crete, Nebraska By C R Johnson and C F Keech Pp v+94+2 plates 75 cents Professional Paper 302–A Phosphate Deposits in Northern Alaska By William W Patton, Jr, and John J Matzko (Exploration of Naval Petroleum Reserve No 4 and adjacent Areas, Northern Alaska, 1944–53 Part 4, Regional Studies) Pp iii+17+6 plates 1 dollar Professional Paper 316–A Regional Geophysical Investigations of the Uravan Area, Colorado By H R Joesting and P Edward Byerly Pp iii+17+3 plates 1 25 dollars Professional Paper 334–A Tables for the Calculation of Lead Isotope Ages By L R Stieff, T W Stern, Seiki Oshiro and F E Senftle Pp iii+40 35 cents (Washington, D C Government Printing Office, 1959) [247

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MASS MEDIA OF COMMUNICATION AND SCIENTIFIC DEVELOPMENTS

IN his Rede Lecture, "The Two Cultures and the Scientific Revolution", Sir Charles Snow pointed out that a knowledge of science among the public was one of four essential conditions if Britain was to meet the challenge of the scientific revolution and, by seizing the opportunities that revolution offers, avoid a steep decline in our standard of living This knowledge was necessary not only for politicians and administrators but also for the whole community, who should know enough science to have a sense of what the scientists are doing This involves, as Sir John Cockcroft has pointed out, a definite effort to remove the language barrier between the public and the scientist, which makes it difficult even for those who are aware that science affects the life of the community to understand how science works and its implications for the community Sir John thought that in the everyday business of administration scientists had mostly succeeded in their effort to explain their work in plain language to politicians, Civil servants, diplomats and business men, but this is only a part of the problem of communication It is no less important that science should be better understood by the man in the street

This is in part a problem of formal education. Increasingly it is also a matter of using effectively the ways of communication at our disposal, and this means especially the mass media of the popular Press, sound broadcasting and television Only if wide and effective use is made of these media can we hope to keep the public sufficiently informed about scientific and technical advances for such discoveries to be put to either personal or public use, and, no less important, for the possibilities of abuse to be eliminated or minimized Nor is this entirely a matter of appropriate techniques or of the standard of public education We need to know much more about the way in which scientific information reaches the public and how much of it really penetrates to the public consciousness, and about the general attitudes, or even prejudices, regarding science and scientists which certainly exist in the minds of the public

These questions have been examined in a series of surveys sponsored by the National Association of Science Writers, Inc, of the United States (Five Longview Road, Port Washington, N Y), and although the reports relate strictly to the United States, their findings and conclusions are unlikely to be entirely invalid in Britain The surveys point to obstacles which exist no less in Britain than in the United States and they suggest ways in which communication could be improved here also, and dangers which threaten in differing degree rather than in differing kind Moreover, while a similar survey in Britain might not establish the existence of a large reservoir of interest in science reporting, with readers, listeners and viewers prepared to surrender other news and entertainment features to become better informed about science, it might well disclose the existence of sufficient interest to halt the present lowering of standards Indeed, failure to do so would provide a damning indictment of our educational system and point to an early decline to a third- or fourth-rate power

The first of these reports, "Science, the News and the Public", describes a sample survey of 1,919 American adults, selected to represent a cross-section of the public, conducted by the Survey Research Center, University of Michigan, and also sponsored by New York University, to ascertain who get what science news, where they get it and what they think about it The second report, "The Public Impact of Science in the Mass Media", describes a nation-wide survey conducted by the same Center and supported by a grant from the Rockefeller Foundation with the specific objectives of ascertaining the size and composition of the major mass media audiences, how science news fits into the news-reading patterns of the newspaper audience, and the conceptions and attitudes of the public relating to science and scientists, determining the size and characteristics of the science audiences of the media, describing the content of science news which has been read, heard and seen, obtaining the science audiences' evaluation of the way in which science news is presented, analysing the social and psychological factors that affect the consumption of science news, examining the effect of differential wording of science news items on the level of reader interest, and estimating the distribution of science information among the public This survey was based on a pilot study in 1955 of a non-random sample of 200 respondants The third report, "Satellites, Science and the Public", describing a national survey of the impact on the public of early satellite launchings, is a follow-up of the main survey It was conducted a year later, and it is focused on the changes revealed in the answers to questions regarding the Earth satellites put before and after the launching of the first satellite

The first report provides evidence that in the United States the mass media could reasonably increase the present cover of scientific developments, and it is argued that, with increasing numbers of students in high school and college, many of whom will be studying science, there should be a great expansion in the demand for science coverage in the channels of popular communication Much of the information in the mass media does reach the public mind, and on the evidence of this survey an impressive amount of this science information is retained The report once again directs attention to the room for improvement in the popular reporting of scientific developments, but beyond the observation that reporters and script-writers, given more training and time in assignments, would be able to provide more details, greater background, better interpretation and, possibly, higher accuracy, the report does not pursue this important theme It is conceded that such changes might help to correct present distortions in the public image of science and scientists and promote the idea that they are part of, not divorced from, contemporary living , but the conclusion stands that science is not constantly covered in the United States and that Americans lack information on which to decide intelligently public matters involving science, scientists, and possibly their own existence

These conclusions are substantially supported by the larger study Available evidence suggests that even allowing for a possible boom in science news stimulated by the launching of Earth satellites, the mass media are transmitting only a microscopic part of the supply of scientific information potentially available Since 76 per cent of the sample could recall one or more science items they had read or seen recently, 64 per cent recalling at least one item from the newspapers, 34 per cent from magazines, 13 per cent from radio and 41 per cent from television, it would seem that the demand has been greatly under-estimated

In the United States the mass media together cover all but 1 per cent of the private dwelling units of the country and at least a quarter or a third of every social category uses three media Papers appear to be the primary source of general views, and while the greatest change in the media used during the past decade has been the rapid spread of television, the written media have held their audiences well The combined science audience appears to include three out of four adults, and newspapers are the most important source of science news and radio the least Papers, magazines and television are mutually supplementary as sources of science news, but radio is weak both as a primary and secondary source Newspapers appear to take a key role in transmitting both science and medical news to this large science audience and there is generally a positive reaction towards science as it is presented in the mass media

The report then analyses in a separate chapter more particularly the newspaper audience, the magazine, radio and television audiences being considered in a following chapter While it is clear that science news is not read solely by the intellectual *élite*, the survey suggests that reading of non-medical science news is associated with a cosmopolitan and rather intellectual orientation towards news content, while medical news tends to be read by those with a more personalized local point of view Education and income-levels are reflected in science reading of both types and also in the extent to which actual news items are recalled Even in the social categories least prone to read science news, a sizeable minority is reached by the presentation of science in the Press

As regards magazines, the survey points to a relatively *élite* audience compared with the other media, and in general magazine readers of science in the United States appear to be highly satisfied with the way their medium presents science The newspaper is the most important supplementary medium for these readers The radio audience of science, however, appears to be scanty, and although the audience is spread very evenly through the population, the completeness and accuracy of science news on the radio receive adverse comment Again, the newspapers provide much supplementary information for this group Television has not yet challenged the lead of the newspaper, and its potentialities for the transmission of science news are regarded as largely unexplored, but there is evidence in this report that a good deal of care will be required in developing this field if science information is to be presented without exaggeration and distortion

Subsequent chapters consider briefly the forms and channels in which science news is presented in relation to effective presentation, but the data are too scanty for more than tentative evaluations of presentation to be made The evidence indicates that additional interest is more readily stimulated the more a person is already interested in science, but nevertheless more vivid or stimulating presentation does affect those who are not already interested or trained in science Education in science is, however, important as providing both the necessary background and a sensitivity to scientific topics The evidence presented in this report fully supports the argument that sufficient general science should be a part of the education of every citizen to enable him or her to understand how science works, what it is about and something of its meaning in the world to-day

This factor can obviously determine attention or indifference to science news and the report seeks to analyse these motives Most of those interviewed were willing to have other news cut to get more science news in the papers, but the reasons for interest in science most cited were fairly broad, and orientation to science seemed to serve the broader functions of making sense of the world and helping to manage one's relations to it This, of course, indicates the importance of presenting science in its context and not presenting pieces of information or facts in isolation

Finally, the survey examines the current attitudes to science and the world which go so far to determine the public understanding or misunderstanding of science as it is presented to them to-day When asked to strike a balance of the effects of science on the world the public overwhelmingly stresses the good effects These are seen primarily as improvements in health, standard of living and technological advance, and the direct ill-effects on the world are seen almost entirely in terms of the destructive potential of nuclear energy Concern about the detrimental effects of science on the social order and the deviating traits of scientists was an underlying theme, and the report, besides noting that people who are highly concerned about such issues are likely to advocate limiting scientific research, points out that in times of crisis these ambivalent attitudes could lead to a more negative picture of science.

The report on the survey of the public impact of early satellite launchings shows that almost half the adult population of the United States became aware of the satellites in a single year. 90 per cent had heard of the satellites by mid-1958 compared with less than 50 per cent a year earlier. Less than one-third of those aware of the satellites thought of them as having primarily an immediate scientific purpose; about one-fourth knew of no purpose. Both awareness of the satellites and of their scientific purpose was related to the education, income and number of media used by the person, and the evaluation of science and scientists was overwhelmingly favourable in both these comparative surveys. Within the newspaper audience there was a moderate increase in readership of science.

The comparative survey provides further evidence that awareness of a scientific event or finding can be stimulated in all strata of the public if enough news concerning the event can be made available to the audience, and that it is probable the public reaction to a scientific event is largely determined by a desire to understand and master the world as seen by the individual. Increase of interest in a particular area of science due to a major break-through in knowledge or achievement is unlikely to stimulate interest in other scientific areas unless the public sees definite links between the areas. The pattern of public reactions to science and scientists is a complex and pervasive phenomenon, and the generally favourable attitude to science and scientists is regarded as more stable than the public's notions of the boundaries of scientific endeavour. Science and scientific events, however, do not operate in a vacuum and some aspects of the public's evaluation of science are liable to change. It seems likely that the public is less concerned with what science is than with what it accomplishes.

These generalizations are scarcely new to the scientific writer and are indeed part of the everyday technique of communication. On the actual technique of communication, however, these reports throw little light. They are of interest to British readers rather for the attention they direct to certain dangers as well as to trends and objectives in the use of mass media and perhaps especially to the fundamental importance of education. They underline, indeed, the importance of the investigation of the educational potentialities of the mass media on which Mr. J. Trenaman has been engaged for the past three years with the support of the Nuffield Foundation, and provide substantial evidence that effective use cannot be made of the mass media, and perhaps especially of television, if our educational system is defective. Shortcomings there will not be remedied by the mass media.

Indeed, if one generalization is to be drawn from these reports, it is that the mass media are unlikely to prove a reliable method of increasing the public understanding of science unless the mass audience has itself already been prepared by its general formal education to understand what science is about and the place it takes in the world to-day. Without this the dangers of abuse, particularly of broadcasting and television, to which renewed attention was directed in the debate in the House of Lords on June 3, and by Mr. H. Carleton Greene, the recently appointed director-general of the British Broadcasting Corporation, in an address* to German business men on April 18, and by Dr. M. Conran in his article on the Third Programme, will remain formidable. There is little in the American survey to suggest that Field-Marshal Smuts was unduly pessimistic in regarding the disappearance of the sturdy, independent-minded, freedom-loving individual and his replacement by a servile, standardized, mass-mentality as the greatest human menace of our time. Indeed, it is almost inherently impossible for the mass media themselves to check this process. Lord James of Rusholme in the Lords debate remarked that one cannot use all the techniques of mass persuasion, appeal consistently to the facile, the uncritical and the escapist, and still talk of freedom.

The debate in the House of Lords did not resolve this issue. It focused attention rather upon the question of public responsibility, and strong support was forthcoming for the view that television, as well as sound broadcasting, should be made entirely responsive to the public interest and, whether in the public or in the private sector, subject to impartial review. Lord James was forthright on the importance of this sense of public responsibility and of television and broadcasting being independent of any political or commercial pressure, so that new facilities could be freely used and in new ways if we are to foster an educated democracy, as critical, as knowledgeable and as free as we can make it.

There was little support in the debate for further extension of television programmes but some for the improvement of programmes and for technical research. Lord Hailsham seemed to stand alone in his reply for the Government in professing satisfaction with the present position and no concern about the possibility of abuse or debasement of standards. This was Mr. Carleton Greene's main concern, however, and, arguing that radio and television are too powerful in the potential long-term effects for their control to be entrusted to either politicians or business men, he points out that once the fairness and impartiality of a broadcasting system become suspect its authority as a source of information is destroyed. He quotes American experience to show how liable this is to happen in commercial television, and he suggests further that available evidence points to the conclusion that commercially controlled broadcasting tends, in the long run, to undermine the intelligence, at any rate, of its constant listeners and viewers, and makes it more difficult for them to appreciate programmes which demand some thought and application. It makes them passive rather than active.

This can be particularly serious for children, and the possibility is the more disturbing in that the American survey confirms so strongly the determining influence of early education brought out in Mr Trenaman's study The most powerful influence in effective communication is the full-time education received in childhood and early youth , and alike in resisting the detrimental or anti-social influences of broadcasting or in realizing the potentialities of these new media for adult education this is the decisive factor It far outweighs the importance of technical improvements in the use of television or sound broadcasting for educational purposes, and though Mr Greene's address at first sight seems to bear only indirectly on the American inquiry, it should be clear that any attempt to improve the use of the mass media to disseminate scientific information and advance the public understanding of science could well fail if it did not take account of this factor, and if it ignored the consequences of political and sectional pressure debasing the media

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* Two Threats to Broadcasting: Political and Commercial Control. By H. Carleton Greene. Pp. 8. (London: British Broadcasting Corporation, 1959.)

Mr Greene does not ignore the beneficial results which a public service broadcasting system can bring and he points out that B B C television has, contrary to expectation, had in England a favourable effect on reading habits rather than otherwise The use of radio and television in schools, however, is quite a separate issue What needs to be emphasized first is the crucial importance of an adequate system of education in the schools if the level of public understanding of science is to be raised That comes first, and no improvements in the techniques of presentation and of using the mass media can compensate for shortcomings there Further, with the realization of the opportunities which television and also sound broadcasting should increasingly offer, if wisely used, for communicating scientific information, there should be a keen appreciation of the irreparable damage that can be done both to the reputation and effectiveness of the medium and to public intelligence if these media are rashly and irresponsibly used

EGYPT AND GREECE IN MEDICAL HISTORY

Ancient Egyptian and Cnidian Medicine

The Relationship of Their Aetiological Concepts of Disease By Robert O Steuer and J B de C M Saunders Pp xii+90 (Berkeley and Los Angeles University of California Press , London Cambridge University Press, 1959) 22*s* 6*d* net

THE authors of this interesting and constructive, though highly specialized, book introduce the problem which they seek to expound by the statement that "throughout the history of medicine the physician has searched for a theory of disease through which he might organize a diversity of data and thus justify his practice by establishing a scientific system" This is an elaborate way of saying that for centuries doctors have been looking for an easy way of practising by rule-of-thumb Even in ancient Egypt this search had begun, although many medical historians have regarded the contribution of Egypt to modern medicine as negligible, because it was magico-religious, and entirely devoid of any rational approach The recent re-examination of the existing medical papyri has placed Egyptian medicine in quite a different category, and has confirmed the view, previously advanced with little supporting evidence, that the Greeks, acknowledged to be the first to base their medical practice upon observation rather than upon theory, drew many of their ideas from the Egyptians The first to profit from the Egyptian impact was the pre-Hippocratic School of Cnidos (on the mainland opposite the island of Cos) Cnidian medicine, however, was apt to confuse symptoms with diseases, and it was not until Hippocrates of Cos insisted upon the need for observation, and upon the importance of prognosis rather than diagnosis, that the great era of Greek medicine was inaugurated

The present work deals with the link between Egypt and Cnidos Both were preoccupied with the idea of putrefaction as a cause of disease, and with the means of preventing it The prevention of corruption had been carried to a fine art by those who embalmed the human body after death, and this process of mummification was based upon the principle which was followed also by those who sought to heal the living body by getting rid of putrefaction within it It was alleged that disease was caused by the *materia peccans* in the fæcal content of the bowel It logically followed that treatment must consist of eliminating the noxious agent or putrefying matter by purgatives or enemata

The writers of the book under review give many examples of this etiological concept, culled from various papyri, especially the "Papyrus Anonymous Londinensis", besides a number of Greek writings Although the Cnidian notions appear to have been supplanted by the idea of the humours, favoured by Hippocrates and the Coan School, the two opinions were to some extent united when it was admitted that even the humours might be corrupt or putrefying This idea paved the way for the doctrine of the ethereal 'miasma' as a cause of disease, an idea which held the field for centuries in various guises until at length the pathogenic nature of bacteria was demonstrated The relationship between the ideas of Egypt and those of Greece is a significant chapter in the history of medicine, and Dr Steuer and Prof Saunders are to be congratulated on their careful and well-documented study of the putrefactive principle in ancient writings Besides the 55 pages of text, there are an appendix expounding the views of Galen on the matter, and another, suggesting that air-borne disease may have been envisaged even in ancient Egypt There are twelve pages of informative notes and a bibliography, as well as an adequate index

DOUGLAS GUTHRIE

THE MOVING FRONT OF CARBOHYDRATES

Advances in Carbohydrate Chemistry, Vol 13

Edited by Melville L Wolfrom in association with R Stuart Tipson Pp xi+387 (New York Academic Press, Inc , London · Academic Books, Ltd , 1958) 88*s*

VOL 13 of "Advances in Carbohydrate Chemistry ' presents ten reviews on specialized topics of carbohydrate chemistry Trends of present-day sugar chemistry are reflected in the titles of some contributions and are interwoven in the text of others Interest in amino-sugars has grown considerably over the past two decades with the recognition that biologically active mucopolysaccharides and mucoproteins such as heparin, blood group specific substances, virus hæmagglutinin inhibitors and gonadotropins contained N-substituted 2-amino-2-deoxy sugars Furthermore, sialic acids, containing as nucleus an amino-sugar, have established themselves as regular components of mucoproteins and some mucolipids of animal origin and as constituents of the membrane of certain bacteria Interest in the impact of alkali on simple sugars, oligosaccharides and polysaccharides has been revived by the discovery of enzymes catalysing aldose – ketose isomerizations, by the realization that the glycosides of β-hydroxyaldehydes and β-hydroxyketones are sensitive to alkalis and by the recognition that the products of alkali degradation of polysaccharides afford valuable information as to the linkage of the constituent units Finally, the problem of the conformation of the individual sugars enters into nearly every discussion on the reactivity of the carbohydrate concerned

The topic of sugar-ring conformational analysis attended to in previous volumes is extended by F Shafizadeh to the formation and cleavage of the oxygen ring in sugars· Shafizadeh discusses various aspects of the interconversion of the cyclic forms and acyclic forms of a sugar The inductive effect of the hydroxyl groups on the reactive function and the steric effects are well exemplified The nitrous acid deamination of amino-sugars provides further proof of the profound effect the nature of the adjacent group and the configuration and conformation of the molecule have on the reaction A concise summary of the preparation and physical properties of the methyl ethers of D- and L-glucosamine, D-galactosamine, D-allosamine and D-altrosamine is provided by R W Jeanloz, who has made many contributions to this field The availability of these ethers renders it possible to apply the methylation procedure of structural analysis to oligo- and poly-saccharides containing amino-sugars

In the chapter on sialic acids, F Zilliken and M W Whitehouse give a useful account of the composition, structure, determination and distribution of the various sialic acids (N-acylated neuraminic acids) The presentation would have gained in appeal if the authors had stressed the unique arrangement of the functional groups in neuraminic acid (the common parent compound) and interpreted the remarkable properties of this group of substances on the basis of this arrangement With regard to the linkage of sialic acid in animal mucoproteins it is safe to say that the acid is invariably found as a terminal unit , it seems improbable that it serves as "a chemical bridge between polypeptides and polysaccharides" (p 238) There is no evidence that the influenza-virus particle has any other enzymic activity than that of an α-neuraminidase (see p 260) Perhaps I may be allowed to point out that the molecular structure of neuraminic acid, proposed in 1955, was conceived not so much on speculation as on the hard facts that N-acetylneuraminic acid was convertible under mildest alkaline conditions to pyrrole-2-carboxylic acid and that the same pyrrole was obtained by aldol condensation of D-glucosamine with pyruvic acid These findings (*Nature*, **176**, 881 , 1955) left no doubt on the position in neuraminic acid of the key functional groups and favoured Blix's (1955) rather than Zilliken's (1955) empirical formula of N-acetylneuraminic acid

The Lobry de Bruyn – van Ekenstein transformation of sugars in all its aspects and side-reactions (formation of deoxyosones) is very logically presented by J C Speck The accumulated results show that these transformations proceed by an enolization type of mechanism and that a common intermediate is formed in the aldose – ketose isomerization and the 3-deoxyosone production The alkaline degradation of polysaccharides also begins at the reducing end of the molecule with enolization and proceeds stepwise through the anhydroglycose chain In such a peeling process the reducing end group is liberated from the chain by elimination of the rest of the chain as a glycoxy anion The released end-group forms an α-dicarbonyl structure which is rearranged by a Cannizzaro type of reaction to yield saccharinates R L Whistler and J N BeMiller have cogently summarized this field The reaction schemes clearly indicate the dependence of the type of saccharinate formed (ordinary, meta- or iso-saccharinate) on the structure of the glycosyl units of the polysaccharide. Incidentally, treatment of unsubstituted N-acetyl-D-glucosamine by mild alkali results in the formation of D(+)-5-dihydroxyethyl-3-acetamido-furan, and not in that of glucoxazoline (p 305) The life-work of J W E Glattfeld on four-carbon saccharinic acids is reviewed by J D Crum

The story by G V Caesar of starch nitrate, the oldest known and industrially the most important starch derivative, reads like a 'thriller' I Goodman reports on glycosyl ureides and L Stoloff contributes a chapter on polysaccharide hydrocolloids of commerce The important formazon reaction with its implications for the structure of sugar phenylhydrazones and phenylosazones and with its use as a tool for elucidating the structure of polysaccharides is comprehensively described by L Mester

It seems most appropriate that the opening chapter is dedicated to the memory of Carl Neuberg, who has made outstanding contributions to many of the topics discussed in this excellent volume

ALFRED GOTTSCHALK

PRELUDE TO SPACE RESEARCH

Vistas in Astronautics

First Annual Air Force Office of Scientific Research Astronautics Symposium (Co-sponsored with Convair Division, General Dynamics Corporation) Edited by Morton Alperin and Marvin Stern (International Series of Monographs on Aeronautical Sciences and Space Flight Division 7 Astronautics Division, Vol 1) Pp xxi+330 (London and New York Pergamon Press, 1958) 105*s* net

IN February 1957 satellites and space exploration were things of the future, and the organizers of the Astronautics Symposium held in that month at San Diego were at pains to secure serious papers on the subject from recognized scientists, rather than to encourage speculative contributions Consequently, the title of this book, which provides a record of the papers read at the Symposium, is slightly misleading most of the papers remain earthbound (if we stretch this phrase to include satellite orbits) , only a few flutter off into the depths of space

The book is divided into six sections of roughly equal length The first, entitled "Re-entry", includes an excellent paper by C Gazley describing the deceleration and heating of a body entering a planetary atmosphere from space, and several contributions on the aerodynamics of re-entering space-vehicles

Part 2, on "Tracking and Communication", includes a detailed description of the 'Microlock' radio instrumentation system for satellites The third section, on the environment of a space vehicle, has several expert surveys of particular topics, such as F L Whipple's paper on the "Meteoric Risk to Space Vehicles" and H V Neher's terse 1½ pages on cosmic rays In Part 4 the possible propulsion systems for space travel are fully discussed Part 5 is devoted to orbits, and includes a 39-page paper by H Oberth, on "A Precise Attitude Control for Artificial Satellites" Part 6 is entitled "Human Factors", and covers space medicine and legal problems

The individual papers in the volume differ greatly in their length, tone, technicality and worth The book can be recommended for its many good technical papers, most of which have stood the test of time well, but there are a few half-page contributions which scarcely deserve permanent reproduction in book form, and the frontispiece, a full-page photograph of the brigadier-general commanding the Air Force Office of Scientific Research, seems rather out of place in a technical book. D. G. King-Hele

EXPLOSIONS IN SOLIDS

Fast Reactions in Solids

By F P Bowden and A D Yoffe Pp ix+164 (London Butterworths Scientific Publications, New York Academic Press, Inc, 1958) 40*s*, 7 dollars

THIS book is a sequel to the authors' earlier (1952) monograph "The Initiation and Growth of Explosion in Liquids and Solids" It deals with subsequent work on the same problems and more particularly with the mechanism by which a crystalline explosive decomposes when subjected to heat, light shock or nuclear radiation Like its predecessor, the book does not attempt to give a comprehensive treatment of the whole field but rather to focus attention on salient developments in the study of explosives and especially on those areas to which the work of the authors and their colleagues has contributed In this it is most successful and it is a stimulating and attractive volume

Chapter 1 is a brief (4 pages) introduction and sketches the plan of the book Chapter 2, which gives an account (13 pages) of the slow decomposition of crystals, is based mainly on silver azide Chapter 3 is longer (25 pages) and more diversified Under the general title of thermal explosions it gathers a varied, though not always clearly organized and interrelated, collection of theory, simple calculation and experiment It is an important chapter to the remainder of the book, for the ideas of thermal explosion theory outlined here are repeatedly applied in this and subsequent chapters The importance of a molten zone to reaction propagation is also introduced In Chapter 4, the structure and stability of the inorganic azides are reviewed (12 pages) in terms of electron sharing between the metal atom and the azide group, this concept is one of the important new points of view this book adopts Chapter 5 (31 pages) on initiation of explosion by shock is closest in theme to the previous monograph An account is given of recent work on initiation by impact, flying particles and shock waves, by friction and by ultrasonic vibration Mechanical initiation is thermal in origin, but 'mechanical' factors such as the disintegration of liquids and solids play a part Chapter 6 (25 pages) reaches a basically similar conclusion about initiation of explosion by flash photolysis The azides are again the principal subject and the concepts of Chapters 3 and 4 are applied in interpretation Decomposition and ignition by nuclear particles and high-energy radiations are dealt with in Chapter 7 (11 pages) High-energy particles provide a convenient method of introducing large amounts of energy into molecularly small regions of the crystals, and the experimental evidence so far is that the activation of a small number of adjacent molecules may not be enough to cause explosion In Chapter 8 (7 pages) the mysterious, spontaneous explosions which occur during crystallization of lead and mercurous azide are described and discussed The first part (7 pages) of Chapter 9 on the fast growth of explosion deals with thin films and the deflagrations and "low velocity detonations" which occur The second part (9 pages), which contains some very striking photographic records, discusses small single crystals undergoing explosive decomposition

This is the arrangement of the text Each chapter after the first has its own 'conclusion' summarizing in broad generality the trends the authors feel significant and it is often helpful to read these before their chapters Perhaps the reader would have been helped still more had the principal subdivisions of the chapters been listed with the contents The text is prefaced by a useful list of names and formulæ of most of the explosives discussed and followed by a set of eight appendixes which are up-to-date short tables of various properties There are good author and subject indexes

It is not the duty of a monograph of this nature which concentrates on recent work in a changing field to supply an extensive background, the appearance last year of M A Cook's formidable "Science of High Explosives" helps to meet this need This book is modern and reliable and the few errors other than trivial misprints that exist, such as the apparent application of le Chatelier's principle to a non-equilibrium process, the occasional use of 'inorganic compound' where 'ionic solid' is intended and of the erroneous $Cu_2(N_3)_2$ and $Au_2(N_3)_2$, may arise from compression and from production of such an up-to-date monograph Above all, the experimental work from the authors' laboratory has a lucid quality which permits it to speak for itself without laborious argument Perhaps 'photogenic' is an apter word to do greater justice to the brilliant photographs which have been obtained and which so admirably illustrate the text Peter Gray

APPLICATIONS OF STATISTICS IN PHYSICS

Statistical Physics

By L D Landau and E M Lifshitz (Course of Theoretical Physics, Vol 5) Translated from the Russian by E Peierls and R F Peierls Pp x+484 (London Pergamon Press, Ltd, 1958) 80*s* net

IN abandoning the general practice of considering classical statistics, quantum statistics and thermodynamics as virtually separate subjects, the authors have produced a book in which the three have been combined with considerable success Although no concessions have been made to the mathematically under-privileged, the importance and significance of the underlying physical principles have not been neglected so that the honours degree student, irrespective of his mathematical attainment, will find much to stimulate his interest in, and to clarify his ideas on, this the most fundamental branch of physics

The initial chapters are devoted to the establishment of general principles by first laying the statistical foundations, then deriving the principal thermodynamic quantities and relations associated with the macroscopic state and finally obtaining the standard distribution functions, both classical and quantum Then follow admirable comprehensive treatments of particular applications to closed systems in thermodynamic equilibrium, some examples of which are perfect and real gases, condensed bodies, solutions, chemical reactions, fluctuations and surface phenomena A chapter on the symmetry of macroscopic bodies could well be omitted as the treatment is too condensed for all but professional crystallographers, and for them it is unnecessary

There are some weaknesses in the general presentation The style is occasionally laboured and an improvement in the continuity could be effected by including in the text the material added in numerous footnotes Further, it is surely unnecessary to derive first a dimensionless expression for entropy into which later must be inserted Boltzmann's constant Again, after the excellent exposition of the basic statistical principles it is surprising that reference should be made to both the specific heat and the Gibbs free energy per molecule Finally, the authors depart in several instances from the conventional in their use of thermodynamic terms , in particular, by "adiabatic" they always mean "reversible adiabatic"

H Steeple

THE GREAT LAKES

Geology of the Great Lakes

By Prof Jack L Hough Pp xviii+313 (Urbana, Ill University of Illinois Press, 1958) 8 50 dollars

FORTY-FOUR years have passed since Leverett and Taylor published their classic work on the history of the Great Lakes During much of the last twenty-seven of these Prof Hough has been engaged on studies of the various aspects of this great group of inland waters There has been a growing need for a summary of the large amount of work that has been accomplished in the interval

The book is divided into two parts The first deals with the topography and hydrology of the present lakes and the deposits on their floors, as well as the pre-glacial and glacial history of the region in general terms The latter is inevitably a simple outline which forms the basis for the more important second part of the book

Part 2, comprising rather more than half the book, deals with the history of the stages of evolution of the lakes as bodies of open water fluctuating in extent, with changes in the position of the oscillating front of the ice sheet to the north The series of outlets of the lakes to the Mississippi, to the Mohawk and Hudson valley, to Lake Erie and the St Lawrence, and to the St Lawrence via the north-east corner of Lake Huron and the Ottawa River came into action repeatedly The story now unfolded is substantially more complicated than the account of Leverett and Taylor, and the work is very much better documented, in consequence of the research by many workers, including substantial contributions from the author himself This applies particularly to revised and more detailed correlation of events over the vast area involved

Particularly noteworthy parts of the book are the detailed but concise critical assessments of the evidence on which correlation is based, a valuable correlation chart based with an absolute dating scale on carbon-14 measurements, and among the many text figures 23 diagrams, summaries of the successive stages in the fluctuation of the extent and outlets of the lakes throughout late and post-glacial time The large-scale southerly tilt of the area consequent on the isostatic rise as a result of the progressive de-glaciation of the area introduces complications in the history in the correlation of shore lines, and this is accentuated by the erosion of considerable lengths of the old beaches during later stages of the history of the lakes

The author is to be congratulated on a major contribution to late-glacial geology of the region The text figures are clearly produced and there is an excellent bibliography

S E Hollingworth

ANTING

Phoenix Re-born

By Dr Maurice Burton Pp 224+16 plates (London Hutchinson and Co (Publishers), Ltd , 1959) 25*s* net

FOR many years anting in birds has held considerable fascination for students of bird behaviour So, too, has the mvth of the Phœnix, and when Maurice Burton saw a tame rook disporting himself on a heap of burning straw it led to an association of ideas which was ultimately responsible for the production of this book After thorough exploration of the Phœnix legend, Burton carried out experiments with his tame rooks and a pet jay to determine their reactions to certain substances and to heat He also examined the literature to see whether records of bird and other animal behaviour might reveal anting incidents which had been unidentified Eventually Burton reached certain conclusions which show a clear connexion between Herodotus's account of the Phœnix and the anting of birds

One thing is common to all the substances which cause the anting posture this is heat or the impression of heat In this remarkable book Burton compares the reaction of birds to different substances, examines the theories of anting and comes to the conclusion that anting must be regarded as a posture adopted in moments of unusually intense excitement This may be stimulated autochothonously or through the agency of an external stimulus producing heat or the impression of heat in the mouth Ant-bathing and thermophily are also shown to be closely related to anting proper and all these are related to such habits as the self-anointing of hedgehogs, the effects of catmint and other odorants on carnivores, as well as numerous idiosyncrasies of behaviour among individual birds and mammals, not excluding man himself

The charm of the book lies not only in the emergence of a new theory to an old puzzle , the telling also stamps "Phœnix re-born" as an ornithological thriller of outstanding interest

T H Hawkins

Introduction to Functional Analysis

By Prof Angus E Taylor Pp xvi+423 (New York John Wiley and Sons, Inc , London Chapman and Hall, Ltd , 1958) 100*s* net

LINEAR functional analysis arose partly from Hilbert's theory of space of an infinity of dimensions and its axiomatic formulation by John von Neumann, and partly from Banach's development of Fréchet's work on abstract spaces Good recent books include those by Zaanen and by Riesz and Nagy Prof Taylor's introduction will not displace these books, but can serve as a useful survey of basic methods In lecture form, the material has been tried out on several graduate courses in the United States, and hence is particularly helpful in the early chapters In the first, the algebraic formulation is kept clear of topology , linear spaces, operators and functionals are defined and illustrated by a wealth of examples of each type, so that the novice is gently helped to surmount his initial difficulty of forming some concrete idea of these abstract concepts The second chapter is a reference section on topology , then in the third, the linear space and the topological space are related to provide the concept of the linear topological space, again with many carefully detailed instances of such spaces The reader who studies these three chapters closely will be rewarded with a firm grasp of fundamentals and should then cope readily with the somewhat increased pace of the later chapters giving the general theory of linear operators, spectral analysis and the standard results for self-adjoint, normal and unitary operators The old-fashioned analyst will be pleased to see contour integration employed in the spectral theory, a method much emphasized in some of Taylor's own papers The final chapter, on integration and linear functionals, is intentionally only a sign-post to further reading in this field The book should be particularly valuable to those who need to get some knowledge of the unifying and co-ordinating power of this potent theory without having to make a specialist's study of it T A A BROADBENT

The Birds of the Palearctic Fauna

A Systematic Reference Order Passeriformes By Dr Charles Vaurie Pp xii+762 (London H F and G Witherby, Ltd , 1959) 105*s*

IT has been claimed that birds are systematically better known than any other class of animals, but even for the relatively familiar Palæarctic region a new 'base-line' has become desirable This is here provided in respect of the passerine birds—a second volume is now being prepared to cover the rest—in succession to the corresponding part of Hartert's "Die Vogel der palaarktischen Fauna" of 1903–32 Unlike Hartert, the present author does not give descriptions of species, but only the main points distinguishing one sub-specific form from another , synonymies are brought up to date rather than repeated in full English names are given for all species, with the French and German equivalents where these exist

The present less-rigid outlook on intraspecific systematics is reflected in the emphasis placed on the 'clinal' nature of much of the geographical variation, and previously described races which the author regards as mere stages on a cline or as otherwise unsatisfactory are relegated to the synonymy , races which the author accepts are graded as "well" and "moderately well" differentiated but are otherwise given identical treatment Of special value are the detailed accounts of the ranges of all forms, and these are usefully reinforced by information about the habitat of each species There are also brief indications of extra-limital distribution and of the existence of extra-limital races, the latter being mentioned by name when not too numerous There are doubtless some points on which other experts may differ, but the volume can be welcomed as an up-to-date authoritative work of reference on the systematics and zoogeography of the palæarctic passerine avifauna LANDSBOROUGH THOMSON

The Open Sea—Its Natural History

Part 2 Fish and Fisheries, with Chapters on Whales, Turtles and Animals of the Sea Floor By Sir Alister Hardy (The New Naturalist a Survey of British Natural History) Pp xiv+322+48 plates (London William Collins, Sons and Co , Ltd , 1959) 30*s* net

THOSE who enjoyed Sir Alister Hardy's first book on "The Open Sea" will also enjoy his second, for it has the same virtues it is written with infectious enthusiasm and with a wide knowledge of fish and fishermen He has sailed in both the old and the new *Discovery*, in trawlers on fishing trips and in fisheries research vessels of many lands, so that he brings a vivid sense of actuality into his writing

Beginning with a brief résumé of the fundamentals of life in the sea, the author goes on to describe what a fish is and how it lives and moves Then follow chapters on particular fish and fisheries The herring is given pride of place with a short account of its history and of the research work on it right up to the present day After two chapters on the bottom fauna, we return to fishing with descriptions of different types of gear and chapters on plaice, elasmobranchs and gadoids The over-fishing problem is not neglected, and indeed in many places throughout the book the author shows how the knowledge we already have could be applied to improve or increase the fisheries He ends with the plea that the division of the North Sea into northern and southern spheres of research should be abandoned in favour of a united effort covering the whole area

There are chapters also on the animals of the ocean floor, on parasites, particularly of fish, on reptiles (not omitting the sea-serpent) and on marine mammals

No attempt has been made to cover the systematics or physiology of fish This is a natural history of the creatures living in the open seas around Britain and there can be few who will read it without learning something new and interesting

Mention must be made of the excellent illustrations Many of the plates are reproductions of the author's own delightful water colours The photographs many by Dr D P Wilson, are outstanding and include some wonderful shots of whales and courting fish S M MARSHALL

Flora of Peru

By Rogers McVaugh (Field Museum of Natural History Botanical Series, Vol 13, Part 4, No 2) Pp ii+569–818 (Chicago Field Museum of Natural History, 1958) 3 75 dollars

THIS part continues the Flora of Peru with the account of the difficult family, Myrtaceae, contributed by Prof Rogers McVaugh, of the University of Michigan The bulk of the species belongs to two large genera, *Myrcia* and *Eugenia* The author is to be congratulated on his carefully prepared keys and long specific descriptions There are no illustrations

SPECTROSCOPIC IDENTIFICATION OF ALPHA-EMITTING NUCLIDES IN BIOLOGICAL MATERIAL

By Prof W. V. MAYNEORD, C.B.E., and C. R. HILL

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IN connexion with a programme aimed at the identification and measurement of the radioactivity of the human body and its environment[1-4], an attempt has recently been made to undertake spectral analysis of the alpha-activity of normal biological materials The most satisfactory general method of analysing alpha-activity is to measure the size of the individual pulses due to electrons which are produced when the alpha-particles are made to spend their full energy on ionizing a free electron gas In the past, attention has been directed largely to materials having moderately high specific activity and the gridded parallel plate ionization chamber has been the instrument most commonly used[5-8] This type of chamber is not, however, suitable for the analysis of materials of very low activity, for which a large source area and a low background counting-rate are essential In order to provide a large source area, Lonati *et al* have designed an instrument in which the source material is spread on a large metal sheet, which is afterwards rolled to form the outer member of a cylindrical electrode system, a grid being situated between the emitter and collector[9] The background counting-rate of their instrument is still appreciable and due, in part at least, to the large areas of metal surface exposed to the counting volume, and to contamination on the grid wires The use of a cylindrical or spherical arrangement can, however, largely obviate the need for a grid in overcoming line broadening due to positive ion effect[10] and has been exploited successfully by Ghiorso in an early instrument[11] If, in a gridless chamber, the sensitive volume is surrounded by material having very low alpha emission, the background counting-rate corresponding to alpha-particle energies may be made very small Such an instrument has been built by us at the Institute of Cancer Research Royal Cancer Hospital and has proved to be capable of analysing the alpha-activity of a wide range of normal biological materials

Description and Performance of the Instrument

The instrument consists essentially of two concentric cylindrical electrodes of length 53 cm and radii 15 and 0 2 cm , respectively The material to be analysed is mounted on the metallized surface of a sheet of aluminized cellulose acetate, lining the inner surface of the outer electrode, and a potential of minus 3 kV applied relative to the inner, collecting electrode The electrode system is enclosed in a vacuum-tight steel tank containing a mixture of 90 per cent argon and 10 per cent methane at atmospheric pressure Under these conditions the theoretical spectral line-width due to positive ion effect is 210 keV at 5 5 MeV The line-width obtained in practice is rather greater as a result of contributions from amplifier noise and self-absorption in the uncollimated source As a result of mounting the source on aluminized cellulose acetate film (which itself has a surface emission of about 3 alpha-particles per hr per 1,000 cm^2 compared to stainless steel 100, brass 100, aluminium 150) and of the relatively small area of other surfaces exposed to the counting volume, the background counting-rate due to surface emission is only 20 counts per hr in the energy-range 4–9 MeV and for a useful source area of 4,000 cm^2. Due, however, to the presence of radon, originating, it is believed, mainly from the surface of the pressure vessel (which was originally built for another purpose and is impossible to clean satisfactorily), the actual background is somewhat higher than the above figure By continuously circulating the chamber gas over charcoal cooled in a solid carbon dioxide–alcohol bath, the radon background, which appears as a three-line spectrum of radon, radium A and radium C′. is maintained constant at 70 counts per hr , giving a total background of 90 counts per hr

The ionization chamber is used with *EKCO* 1049 *B* head and main amplifiers and a *CDC* 100-channel pulse-height analyser This combination provides good stability of recording and, when purity of the chamber gas is maintained by continuously flowing over calcium turnings at 350° C , overall drift can be kept within 100 keV over a period of several days

Preparation of Sources

The sources, which normally consist of a partially insoluble ash of uncertain chemical composition, are prepared by grinding (by hand or in a ball mill) followed by spraying in the form of a suspension in water on to the cellulose acetate sheet, previously wetted with dilute 'Teepol' solution A thin layer of sodium silicate solution is usually sprayed on top of the film so formed (0 03 mgm /cm^2 sodium silicate) to act as an adhesive[12] By this process it is possible to prepare sources which under a microscope appear to consist mainly of particles of about one micron diameter, spread with good uniformity

Results

As illustrations of the use of this technique, spectra obtained with our equipment are shown in Figs 1–4

A popular breakfast cereal, stated to contain "100 per cent whole wheat" and having a total specific alpha-activity of 32 × 10^{-12} c per gm of ash (Fig 1), evidently contains two long-lived alpha-emitters, radium-226 and thorium-228 (RdTh), and their daughters Most of the radon-222 escapes from the thin source and is removed from the system by the radon trap, so that it and its daughters do not appear

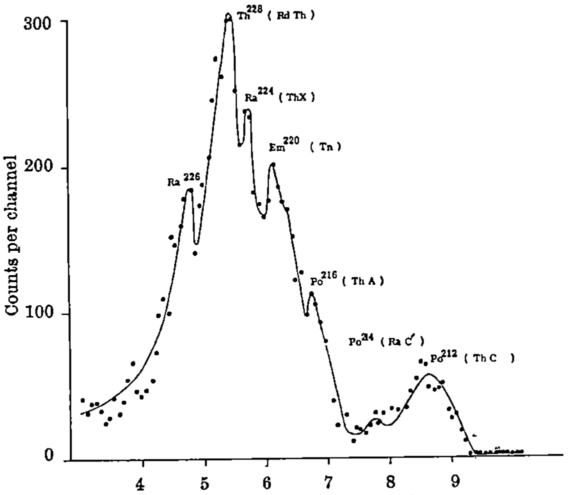

Fig 1 A breakfast food '100 per cent whole wheat' Counting time 24 hr

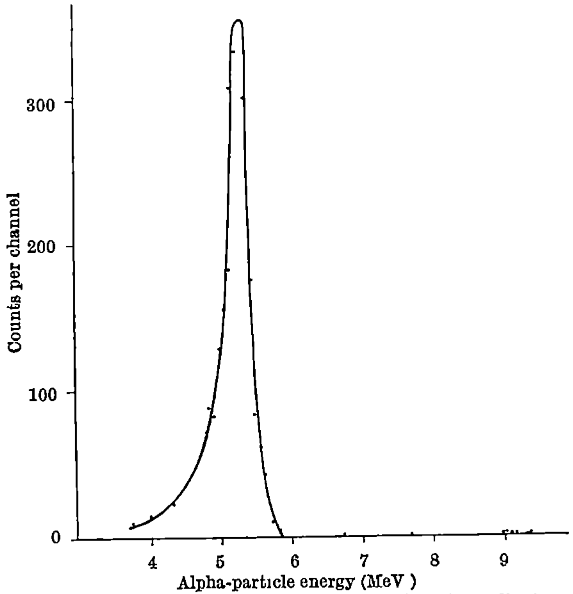

Fig 2 Grass ash Total specific alpha-activity 6 4 × 10^{-12} c /gm Counting time 36 hr

from the spectrum to be in equilibrium with radium-226 Uranium-238 and thorium-232 are absent and the thorium-228 must therefore be presumed to originate from radium-228 (MsTh 1) rather than by metabolic uptake of the element thorium A similar spectrum, but showing relatively higher radium-226, has been obtained for Brazil nuts, which are known to have very high alpha-activity[3], these results have been published elsewhere[4].

Measurements have been made in these laboratories of the total alpha-activities of grass samples taken from various localities[13], and values found in Great Britain have ranged from 1 0 to 170 × 10^{-12} c per gm of ash Spectra of the form shown in Fig 2 have been obtained from all the grass samples that we have analysed so far, which have been collected from several different parts of the country It will be seen that this spectrum is of different form from that of Fig 1, most of the activity being concentrated in a small energy-range While it is not possible from our spectral evidence alone to decide with confidence whether the nuclide concerned is polonium-210 (5 30 MeV) or plutonium-239 (5 14 MeV), evidence from chemical analysis and from the build-up of activity with time, after ashing at 500° C , has established that the nuclide is, in fact, polonium-210 in the presence of lead-210 (RaD) From this spectrum we conclude that polonium-210 accounts for some 90 per cent of the total alpha-activity of the grass ash

In view of the known tendency for the kidney of several species to take up polonium[14,15], we have examined the kidney of a sheep that had been grazed in the district from which the grass sample

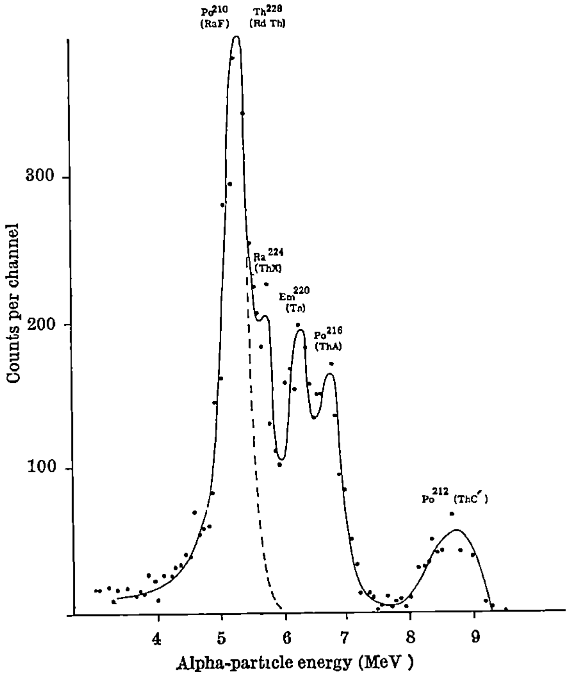

Fig 3 Sheep's kidney Total specific alpha-activity 6 0 × 10^{-12} c /gm ash Counting time 48 hr

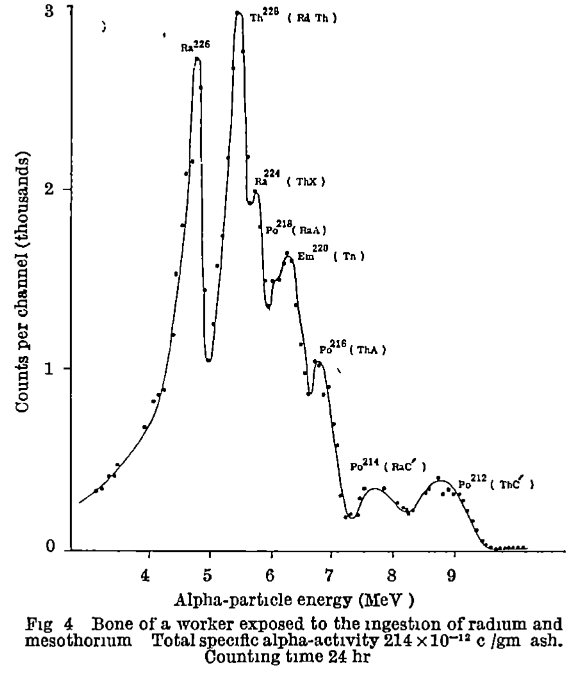

Fig 4 Bone of a worker exposed to the ingestion of radium and mesothorium Total specific alpha-activity 214 × 10^{-12} c /gm ash. Counting time 24 hr

of Fig. 2 was obtained. The total specific alpha-activity was $6 \cdot 0 \times 10^{-12}$ c. per gm. of ash (ash content of wet kidney 1·1 per cent) and the spectrum (Fig. 3) shows that about half the total is due to thorium-228 and its daughters, an observation confirmed by an independent method of estimating thorium series nuclides[2]. In addition, there is a single line of the same energy as that appearing in the grass, presumably again polonium-210. The presence in the kidney of thorium-228 is interesting in view of the absence of thorium-232 and radium-226, although the latter is clearly present in a spectrum taken of the bone of the same animal. The explanation would appear to be that radium, but not thorium, is absorbed by the sheep from its environment and that thorium-228 originates within the sheep by decay of radium-228, being afterwards transported and fixed in the kidney.

The spectroscopy of normal human bone is beyond the capacity of our present equipment, but interesting results may easily be obtained for the bone of those having radium burdens of the order of one-tenth of the maximum permissible level. Fig. 4 shows the spectrum of the bone of a worker who had been exposed to the ingestion of both radium-226 and radium-228 and whose body burden of the former isotope was estimated[2] at $5 \cdot 9 \times 10^{-8}$ c. The presence of radium-226 and of radium-228 with its daughters is clearly demonstrated.

Potentialities of the Method

It seems clear that this type of alpha-ray analysis will prove of great value in the study of the radioactivity of biological materials. We are therefore constructing equipment that should be capable of analysing, with improved resolution, the ash of most living tissues.

We are greatly indebted to our colleague, Dr. R. C. Turner, with whom we have had many fruitful discussions concerning the interpretation of these spectra. Our thanks are due to Mr. J. O. Crookall for the chemical evidence concerning polonium and to Mr. S. P. Newbery for invaluable help with the electronic equipment. We are also indebted to Dr. U. Facchini and his colleagues of C.I.S.E., Milan, who kindly analysed a number of samples for us in their gridded parallel plate chamber before our own instrument was completed.

[1] Turner, R. C., Radley, J. M., and Mayneord, W. V., *Nature*, **181**, 518 (1958).

[2] Turner, R. C., Radley, J. M., and Mayneord, W. V., *Brit. J. Radiol.*, **31**, 397 (1958).

[3] Turner, R. C., Radley, J. M., and Mayneord, W. V., *Health Physics*, **1**, 268 (1958).

[4] Mayneord, W. V., *J. Fac. Rad.* (in the press).

[5] Cranshaw, T. E., and Harvey, J. A., *Canad. J. Res.*, **26A**, 243 (1948).

[6] Bunemann, O., Cranshaw, T. E., and Harvey, J. A., *Canad. J. Res.*, **27A**, 191 (1949).

[7] Glover, K. M., A.E.R.E. *C/R* 2091 (1957).

[8] Facchini, U., and Malvicini, A., *Nucleonics*, **14** (5), 96 (1956).

[9] Lonati, R. D., Facchini, U., Iori, I., Houtermans, F. G., and Tongiorgi, E., *Il Nuovo Cimento*, **10**, 7, 133 (1958).

[10] Wilkinson, D. H., "Ionization Chambers and Counters" (Cambridge, 1950).

[11] Ghiorso, A., Jaffey, A. H., Robinson, H. P., and Weissbourd, B. B., "The Transuranium Elements", II, 1226. Ed. Seaborg, G. T., *et al.* (McGraw-Hill, 1949).

[12] Facchini, U., Forte, M., Malvicini, A., and Rossini, T., *Nucleonics*, **14** (9), 126 (1956).

[13] Marsden, E., *Nature*, **183**, 924 (1959).

[14] Lacassagne, A., and Lattès, J., *C. R. Acad. Sci., Paris*, **178**, 488 (1924).

[15] Stannard, J. N., and Smith, F. A., Univ. of Rochester Report, Atomic Energy Project Contract *W–7401–Eng.* 49 (1957).

THE OHIO STATE UNIVERSITY 360-FT. RADIO TELESCOPE

By Prof. JOHN D. KRAUS
Ohio State University

For some years mapping of the radio sky has been a principal activity at the Ohio State University Radio Observatory. Since it was anticipated that this would also be the case if a larger telescope became available, consideration was given some years ago to a telescope design especially suited for mapping work which would provide the largest possible aperture per unit cost consistent with large sky coverage. The design evolved consists of a fixed standing parabola with a flat reflector which can be tilted to deflect the celestial radiation into it. The general arrangement is shown in Fig. 1. Since the parabola is fixed and supported directly from the ground, a minimum of structure is required. The only moving part is the flat reflector, which is pivoted at ground-level and is required to move through only one-half of the range of declination covered. Although primarily a meridian transit instrument, east–west movement of the feed antenna can provide a small measure of tracking in hour angle. This is not essential, however, in most mapping work.

Scale Model

Experimental work on the design began in 1953 when Robert T. Nash constructed a scale model of the telescope, as part of his thesis work toward a master's degree at the Ohio State University. The parabola of the scale model measured 12 ft. in horizontal length while the wave-length of operation was 1·25 cm. By scaling both the physical size and the wave-length in this manner, antenna patterns can be measured that will duplicate those of the full-size system[1]. Specifically, the system duplicated is a telescope with a parabola 2,000 ft. by 200 ft. operating at 2 metres wave-length or a telescope with a parabola 700 ft. by 70 ft. operating at a wave-length of 70 cm. A photograph of the model is shown in Fig. 2.

Antenna patterns measured by Nash agreed closely with calculated values[2,3]. In fact, the performance of the model was so satisfactory that Nash used it as an actual radio telescope for many observations of the Sun and Moon at a wave-length of 1·25 cm. [4].

Construction of the Full-Size Unit

In 1954 a request was made to the United States National Science Foundation for funds to construct a standing parabola radio telescope with a flat reflector of adjustable tilt, the parabola to be 720 ft. long by 70 ft. high. The minimum wave-

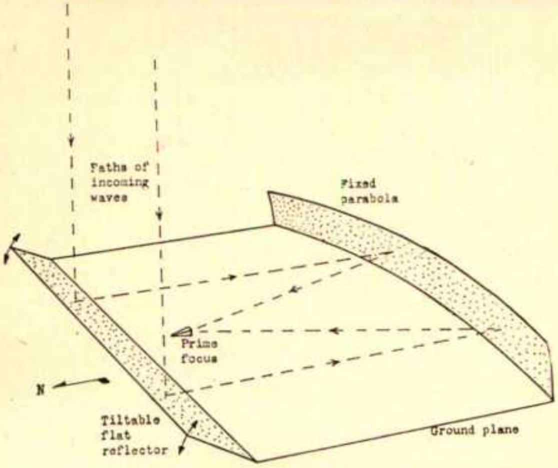

Fig. 1. Principle of operation of the standing parabola radio telescope with flat-sheet reflector. The declination angle of reception is changed by tilting the flat reflector while scanning in right ascension is accomplished by the Earth's rotation

length of operation was to be about 70 cm. and the dimensions were deemed sufficient to provide a significant full-scale test of the design. In 1956 a grant was received from the National Science Foundation for half the amount requested for a parabola 720 ft. by 70 ft. As a result, the plans were modified to build the central half of the telescope so that the parabola would be 360 ft. long by 70 ft. high and the flat reflector of adjustable tilt also 360 ft. long with the possibility that outer sections might be added at some future date. At the suggestion of the Radio Astronomy Panel of the National Science Foundation, the original plans were also modified to make the telescope operate at the hydrogen line (21 cm. wave-length). To maintain surface tolerances at this wave-length required a structure with several times as much steel as in the original design, with a corresponding increase in cost. Two subsequent grants by the National Science Foundation in 1957 and 1958 have brought the total funds provided for the construction of the telescope close to 250,000 dollars.

A sketch of the final design of the telescope is shown in Fig. 3. This sketch is substantially correct, the main discrepancy being that the actual system for elevating the flat reflector uses a winch arrangement instead of a hydraulic cylinder as suggested in the sketch.

The Ohio Wesleyan University provided a 20-acre site for the radio telescope situated about 4 miles from Delaware, Ohio, and near the Perkins (optical) Observatory. The new radio observatory location is known as the Ohio State–Ohio Wesleyan Radio Observatory.

Construction on the telescope began in 1956 with work on the parabolic reflector. The mechanical design of the structure has been the responsibility of Robert T. Nash and the construction also has been carried out under his supervision. The construction crew has consisted of about ten men, most of whom have been Ohio State University students who have worked on the telescope on a part-time basis. The parabola was completed in 1958 and work started on the flat reflector. A view of the completed parabola is shown in Fig. 4. At the time of writing (July) the foundations for the flat reflector are mostly in place and sub-assemblies of the steel structure nearly completed. One section of the flat reflector has been assembled and preliminary tests of the hoisting and locking system carried out.

Specifications

The parabola (360 ft. × 70 ft.) is a section of a paraboloid of revolution with axis coincident with the ground plane and passing through the prime focus. The focal distance is 420 ft. The aperture area is 25,200 sq. ft. or about 0·6 acre. This area is equal to that of a circular aperture parabolic dish antenna nearly 180 ft. in diameter. The reflecting surface of the parabola consists of vertical copper-clad steel wires 0·081 in. in diameter spaced 1 in. between centres. The entire wire-supporting structure of the parabola is hung from the main parabola framework by adjustable brackets in order to facilitate adjustments of the parabola surface if required. The ultimate surface deviation of the parabola is expected to be less than ½ in.

The flat reflector is constructed in movable units 20 ft. wide (east–west) by 100 ft. long in the slant direction. Under normal loading conditions the maximum deflexion of this structure from a flat surface is expected to be of the order of ¼ in. Such movable units are to be mounted with a 40-ft. spacing between centres. Each unit is to be equipped with an individual 3 h.p. electric winch and fast-acting pneumatically operated brake and lock. The winch elevates or lowers the flat reflector unit so that the declination may be changed at a rate of about 5° per min. Twenty-foot beams hinged on each end

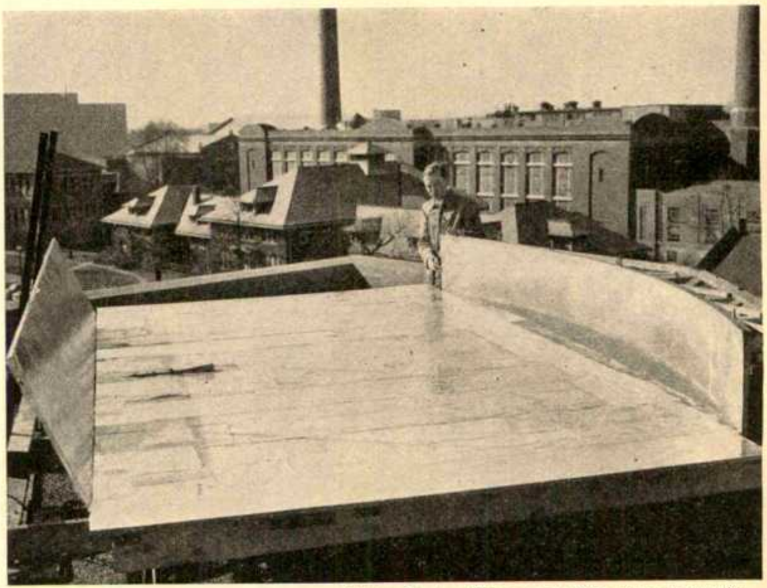

Photo: Dept. of Photography, Ohio State University

Fig. 2. Photograph of scale model built to test the design. The standing parabola is at the right and the flat sheet reflector at the left, with the horn feed antenna at the prime focus just to the right of the base of the flat-sheet reflector

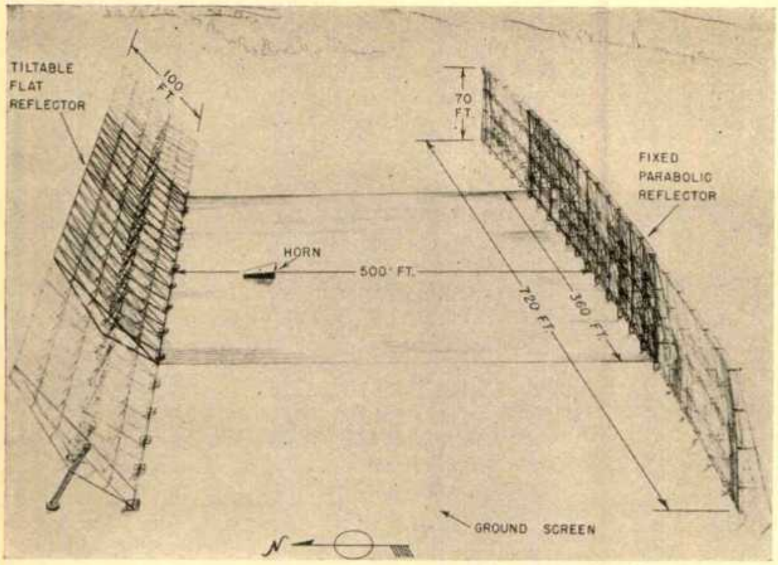

Photo : Dept. of Photography, Ohio State University

Fig. 3. Sketch of the standing parabola radio telescope with flat-sheet reflector being built at the Ohio State University. The central section of the telescope, shown in heavy lines, is the part now under construction, with the end sections, in phantom view, showing possible future additions

will bridge the space between movable units. The actual reflecting surface will consist of the same type of wire with the same spacing as used in the parabola. Although each movable unit of the flat reflector is itself rigid, the flat reflector as a whole is non-rigid since the hinged connecting beams permit each unit to be moved a couple of degrees independently of the adjacent units. The surface of the flat reflector will be monitored with an optical telescope placed at a point on the axis of rotation (along the base of the flat reflector) west of the reflector, and units adjusted individually until the desired declination of all units is attained.

The steel in the parabola and flat reflector has a total weight of about 300 tons while the concrete in all the foundations totals about 1,200 tons. The horizontal ground plane between the parabola and the flat reflector will consist of thin aluminium sheet a few thousandths of an inch in thickness, on flat 'Polyfoam' slabs floated on the surface of a water-filled pond. It is anticipated that the surface of this ground plane can be maintained flat to less than $\frac{1}{2}$ in.

The antenna feed system at the prime focus will be situated on a peninsula covered with conducting sheet which extends south from the base of the flat reflector into the pond. At the higher frequencies horn antennas will be used as was done with the scale model (see Fig. 2), while corner reflectors will be used at lower frequencies. It is planned to operate the telescope at wave-lengths from 15 cm. to 15 metres, a range of 100 to 1. The polarization is vertical. The presence of the horizontal ground plane, which acts as an electrical image plane, reduces the required height of the feed antenna to one-fourth of the value which would be needed if no ground plane were present. Owing to the large horizontal dimension of the standing parabola, the required horizontal dimension of the feed antenna is also small. As a result, the aperture blocking or area of obstruction presented by a single feed antenna is very small, amounting in a typical case to only about one-tenth of one per cent of the aperture of the parabola. Accordingly, a multiple feed can be employed without objectionable blocking of the aperture to provide simultaneous operation over a wide range of wave-lengths. It may even be possible by means of a multiple feed to construct a rudimentary radio camera having as many picture elements as primary feed antennas.

The fact that the feed point is at ground-level completely eliminates the problem of supporting the feed antenna and maintaining its alignment, a problem present in all steerable telescopes. Furthermore, there is almost no limitation to the weight and complexity of the equipment placed at the feed point, so that feed cable losses are eliminated and low-noise amplifiers of the maser and parametric type can be used to best advantage.

At the highest frequency of operation (15 cm. wave-length) the half-power beam-widths of the telescope antenna will be 0·1° in right ascension by 0·5° in declination. (Initially the beam-width in right ascension at 15 cm. will be twice this value, since only the central 180 ft. of the parabola has a reflecting wire spacing of 1 in. and only this portion will be useful at 15 cm. The outer portions have a wire spacing of 3 in. and at longer wave-lengths the entire parabola can be used. However, initially only the central 260 ft. of the flat reflector will be completed. These modifications, which were necessitated by a lack of funds, will somewhat hamper initial

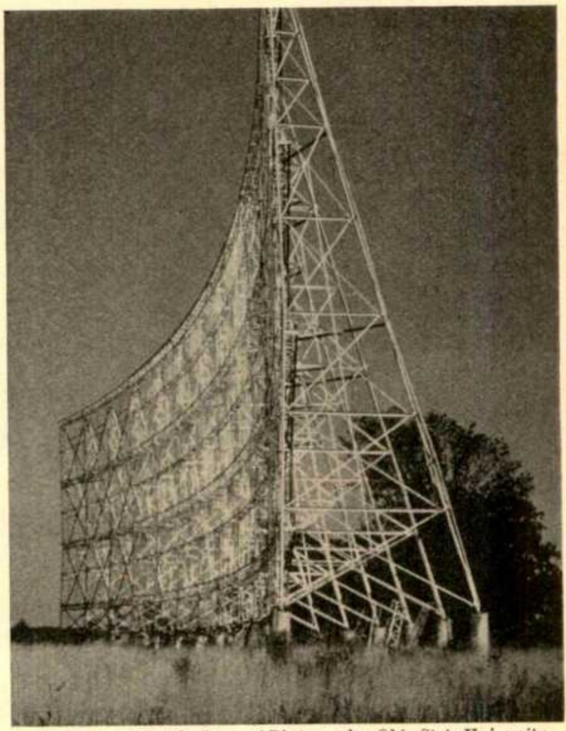

Photo : Dept. of Photography, Ohio State University

Fig. 4. View of the completed 360-ft. parabola from the west

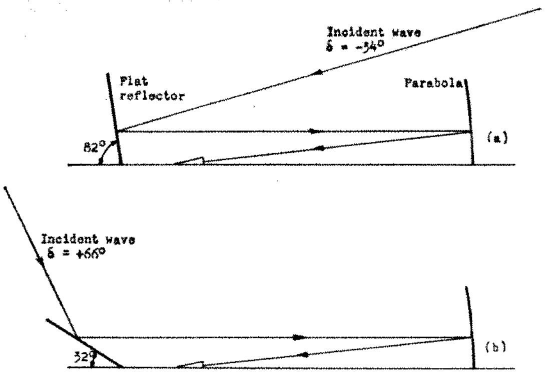

Fig. 5. Diagrams showing extreme positions of the flat reflector and corresponding wave or ray paths

operation of the telescope, but it is hoped that these deficiencies can be remedied at an early date.) This fan beam from the antenna has the same area resolution as a symmetrical pencil beam with a half-power beam-width of about 0·2°. However, the fan beam has the advantage over the pencil beam of reducing the time required for a complete scan of the sky by a factor of about 2·5, and also of providing twice the resolution in the direction in which the sky is scanned. A fan beam is also valuable for the reason that it differs in shape from the pencil beam typical of most steerable dish antennas. Thus, comparisons of source and background surveys made with beams of different shape are valuable in detecting spurious effects, since beams of different shape are, in general, subject to different aberrations.

Although no tracking ability is required for most sky-mapping work, a small measure of tracking can be provided in the new telescope by some east–west movement of the feed antenna. Tests of the displacement of the feed antenna on the scale model showed that tracking of sources in hour angle may be possible for at least 10 min. in time at the highest frequency of operation and for more than 1 hr. at lower frequencies. With vertically polarized feed antennae the electric field vector is perpendicular to the horizontal ground plane, so that the intensity along the ground plane can be a maximum. Under these conditions the telescope is most efficient and operation is restricted to vertical polarization by providing only vertical wires in the reflecting surfaces of the standing parabola and flat reflector.

The flat reflector is designed to tilt to angles between 32° and 82°, as illustrated in Fig. 5. A motion of the flat reflector through 50° (from 32° to 82°) results in a motion of the antenna beam through twice this value, or from a declination of 66° N. to 34° S. (total 100°). The latitude of the telescope site is about 40° N. Since the galactic equator is at about 29° south declination, the telescope will be useful for studies of the region of the galactic nucleus. The fact that the most northerly observable declination is 66° (24° from the celestial pole) reduces the sky area coverage only by a small amount, the unobservable area being only about 6 per cent of the observable sky. Since the slant height of the flat reflector is 100 ft., while the parabola is 70 ft. high, the full aperture of the parabola can be utilized at all declinations south of 40° N. At the most northern declination of operation (66°), the vertical height of the flat reflector will be 76 per cent of the height of the parabola, reducing the useful aperture of the telescope by 24 per cent under these conditions.

The primary or feed antenna radiation will be tapered in order to reduce the minor lobes of the telescope beam pattern to a minimum. This is important in eliminating spurious responses or ghost sources. An important characteristic of the design is that signal pick-up from the ground is minimized, the telescope antenna beam pattern being always directed skyward with the parabolic and flat reflectors providing a measure of shielding from interfering terrestrial signal sources.

The fact that the main part of the telescope has only one moving part, the flat reflector, the position of which can be accurately controlled, means that it will be possible to measure positions of celestial sources to a high precision and with good repeatability.

Conclusion

The new Ohio State University telescope will be an experimental working model of the standing parabola tiltable flat reflector design which should provide useful information for the construction of similar telescopes of even larger size. It is hoped that the telescope will be completed during 1960, at which time a programme of sky-mapping will be initiated that will cover a wide range of frequencies. More detailed sky maps and more accurate spectra of radio sources will be objectives of the surveys. Instrumentation for hydrogen line observations is also to be installed, and observations conducted of the distribution of neutral hydrogen in our galaxy.

[1] Kraus, J. D., "Antennas", 485 (McGraw-Hill Book Co., Inc., New York and London, 1950).

[2] Nash, R. T., master's thesis, Ohio State University (1955).

[3] Kraus, J. D., and Nash, R. T., Ohio State University Radio Observatory Report No. 5 (1955).

[4] Kraus, J. D., Ko, H. C., Nash, R. T., and Stoutenberg, D. V., *Astro. J.*, **61**, 182 (1956).

RADIOCARBON DATING

CONTRIBUTIONS were made by representatives of each of the three laboratories in England which are actively engaged in radioactive dating to a joint session of Sections A (Physics) and H (Anthropology and Archæology) of the British Association at the recent meeting at York. They combined to provide a picture of the basis of the method and its limitations, the trend of future development in instrumentation, and the capabilities of the method as applied to individual problems in the late Quaternary history of the British Isles.

In reviewing the basis of the method of radiocarbon dating, Mr. H. Barker, of the British Museum Research Laboratory, was concerned with the difficulties which had sometimes arisen as a result of the lack of common ground between the archæologist and the physicist. Lack of familiarity with statistical concepts and misunderstandings as to the nature of radioactive decay had led to many misconceptions and the validity of the method had been questioned on wrong premises. The method depends on the fact, predicted and verified by Libby, that the radioactive carbon isotope of mass 14 (known as radiocarbon or carbon-14) is being continually created in the upper atmosphere as a result of the action of cosmic rays Consequently it is distributed throughout the world-wide carbon-exchange reservoir which comprises the atmosphere, the oceans, and all plant and animal life Libby produced sound theoretical argument, backed by practical measurements, for assuming that the carbon-14 is evenly distributed throughout the exchange reservoir and that the level of radioactivity due to this cause has remained the same for many thousands of years This assumption is fundamental to radiocarbon dating, when an organism dies it is cut off from the exchange reservoir, the possibility of it replenishing its carbon-14 by vital processes ceases, and its store of carbon-14 diminishes at a rate determined only by the half-life (about 5,600 years) One can therefore calculate the time which has elapsed since it was alive, from a measurement of its residual carbon-14 activity, provided that one can assume that its original activity was the same as that of a reference sample which has been recently removed from the reservoir The measurement is exceedingly difficult, and limitations in accuracy, imposed by statistical fluctuations in the measurement of radioactivity, result in an error term being associated with each radiocarbon date The correct interpretation of the significance of this error-term requires some familiarity with statistical concepts, and lack of appreciation of this has led to misunderstandings

In the ten years which have elapsed since Libby announced his first successes, there has been a revolution in instrumentation Nowadays, the measurement of radioactivity can be made to a much higher accuracy, and the question arises as to whether the basic assumption of the method still holds good at this new level of accuracy In fact, it seems that a number of minor effects can combine to limit the accuracy Craig showed that isotopic fractionation in plants can result in fluctuations of up to ± 1 per cent in carbon-14 activity from the mean value This corresponds to an error of ± 80 years Fortunately, it is possible to apply corrections for this effect based on mass-spectrometric measurements of the ratios of the other carbon isotopes in the sample and the standard Systematic errors, mainly due to differences in 'recent' standards, have caused difficulties in comparing results between different laboratories In most cases, the errors are quite small, but steps are now being taken to eliminate these differences Very recently, de Vries has shown that the level of activity in the exchange reservoir has suffered cyclic changes of about ± 1 per cent during the past 500 years So far as one can see at present, this effect definitely limits the accuracy obtainable in dating to about 100 years

Apart from these theoretical limitations, it must not be forgotten that the choice of sample plays an important part in the real accuracy obtainable The archæologist has to relate the death of an organism (which is what is actually measured) to an event in which he is interested The environment of the sample is not unimportant, the possibility of sample contamination must not be overlooked, and suitable laboratory treatment applied when necessary to remove contaminating materials such as rootlets and humic acids

Mr W J Callow, of the National Physical Laboratory, also referred to the factors which limit the accuracy of the method, but pointed out that, despite these limitations, the radiocarbon method remains a very valuable technique for chronological studies in archæology, geology, botany, oceanography and allied fields There are now nearly forty laboratories distributed throughout the world which have been, or are, currently engaged in this form of dating Some time ago, it was realized that there was a need for a dating service to be made generally available to workers in Great Britain The laboratories at the Botany School, Cambridge, and the British Museum were occupied in the main with their own programmes, and it was considered appropriate that the new service should be set up at the National Physical Laboratory

The instrumental difficulties are considerable in that the measurement is concerned with levels of radiocarbon concentration ranging from one part in a million million down to zero In the case of recent carbon, this corresponds to the breakdown of about fifteen carbon-14 atoms per min per gm of carbon Detecting and recording these disintegrations requires special techniques due to the low energy of the beta-particles and the low counting-rates involved

In all methods, the first process involved consists of converting the sample to carbon dioxide, either by combustion, in the case of organic material, or by acid treatment, in the case of carbonates In Libby's original method the carbon dioxide was reduced to solid carbon which had to be placed inside a counter because of the low beta-particle energy Due to the low efficiency of the counter under these conditions and the possibility of contamination with radioactive fall-out and naturally occurring radon, this technique has now been abandoned

Both de Vries in Holland and Fergusson in New Zealand have shown that carbon dioxide itself, if sufficiently pure, can be used as the operating gas in a proportional counter, and this technique is being adopted at the National Physical Laboratory As little as one part per million of electronegative impurity such as oxygen or oxides of nitrogen in the carbon dioxide can prejudice the reliable operation of the counter, and hence the accuracy of the measurement The gas preparation equipment at the National Physical Laboratory is therefore designed to produce carbon dioxide of an extremely high degree of purity.

Carbon dioxide is not the only possible counter filling, methane and acetylene are in use in some laboratories Both involve rather more preparatory work, but they are more tolerant of the presence of impurities Acetylene has the advantage of having two atoms of carbon in its molecule, and therefore, under a given set of conditions, the use of it enables one to place twice as much carbon in the counter compared with carbon dioxide or methane methods

Liquid-scintillation counting also provides a possible approach to the problem of measurement, but difficulties in chemical preparation prevent its general adoption

The actual measurements are complicated by the fact that, in normal circumstances, the background counting-rate of the counter would be very much greater than that due to the sample itself, and steps must be taken to reduce its value A heavy steel screen with walls 8 in thick is used to eliminate the effect of local gamma-radiation The screen at the National Physical Laboratory, which is large enough to accommodate a number of counters, weighs more than 23 tons The penetrating meson component of cosmic radiation, against which the steel screen has no effect, is cancelled out by a ring of Geiger counters surrounding the sample counter and connected in anti-coincidence Other screening precautions which have been shown to be advisable and which are incorporated in the equipment at the Laboratory include a mercury shield, which reduces the background due to traces of radioactivity in the steel screen, and a layer of paraffin wax mixed with boric acid which reduces the component due to neutrons which are in turn induced in the screen by the action of the corpuscular component of cosmic radiation This neutron flux will also be monitored continuously Since accurate measurement of these very low disintegration-rates necessarily takes a long time, great emphasis has been placed on the reliable operation of the associated electronic equipment The instrumentation at the National Physical Laboratory is based on the use, wherever possible, of high-stability circuits as used in computers, and of transistors instead of thermionic valves The equipment includes a comprehensive system for automatic recording, and a mass spectrometer has also been purchased in order that corrections can be applied for isotopic fractionation effects The equipment is nearing completion and should be in operation in the near future

Dr H Godwin described how the method is being used in the Cambridge Sub-department of Quaternary Research to give an absolute time-scale to the history of events during the Late Quaternary period, that is, the past 35,000 years or so The apparatus, designed and built by Dr E H Willis, consists of a proportional gas counter of about 2-litres volume It is shielded by 7 tons of zinc and lead and an anti-coincidence array of Geiger tubes It has a net contemporary count-rate of 28 counts per min and a steady background of 20 7 The equipment was acquired as a result of the generosity of the Nuffield Foundation, but is now maintained by the University of Cambridge

The oldest sample dated so far was from the Arctic Plant Bed from the Lea Valley This gives a date of 26,000 B C for the time when the mammoth was still alive in Britain A date from a later horizon in the valley of the Colne, a tributary of the Lea, shows that the full Glacial Period must have persisted until *c* 11,500 B C After the glaciation, there came a period of climatic oscillation, the so-called Allerød Period The effects of this change can be recognized in deposits at numerous sites throughout the British Isles Carbon dating on material from such sites shows that there was a temporary mild period between 10,000 and 8,800 B C, followed by a return of cold for about 500 years These British dates are in excellent agreement with dates from north-west Europe As a result, British events are now closely tied up with events at the end of the ice age in Europe

Following the Allerød oscillation came the climatic improvement of the Post Glacial Period In the past, pollen analysis has provided a relative time-scale for this period since the characteristic changes in forest composition have permitted the establishment of a sequence of pollen zones applicable, with care, to the whole of the British Isles A series of twelve datings from a site in Cumberland gives a very consistent series of dates for the successive pollen zones It remains to be seen how far these pollen boundaries are truly synchronous across the British Isles or Western Europe

The increased temperature at the end of the last glaciation caused melting of the ice sheets and a rapid rise in ocean-level One effect of this was the flooding of the North Sea and the isolation of Britain from the European mainland Dates measured in Cambridge on submerged peat-beds from around the coast of Britain, together with those made at other laboratories, show that a rapid eustatic rise of sea-level was in progress between 12,000 and 4,000 B C and that the level rose by more than 200 ft

In the derelict raised bogs of Somerset, several prehistoric wooden trackways have been recorded and excavated They appear to have been built in the late Bronze Age at a time when increasing wetness of climate induced flooding of bogs and valleys and caused Bronze Age man to construct these wooden causeways Radiocarbon dating of seven such structures in Somerset and three others in Lancashire, Cambridgeshire and Lincolnshire show that they were built in the period 500–900 B C

The picture which emerged from this discussion is a very hopeful one for the future of radiocarbon dating in Britain Although the method has certain limitations, the work described by Dr Godwin illustrates its great value as a tool for establishing an absolute chronological framework to prehistoric events, and the news that Britain's present limited capacity for radiocarbon dating is to be augmented by the considerable resources of the National Physical Laboratory will be welcomed in many quarters The dates mentioned in the discussion appear in a paper in the *American Journal of Science* Radiocarbon Supplement, Vol 1 (1959), the new international organ for the publication of radiocarbon dates

HAROLD BARKER

MECHANISM OF HORMONE ACTION

By PROF AARON B LERNER

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CELLS have specific functions, for example, adrenal cortical cells produce hydrocortisone, nerve cells form noradrenaline, melanocytes make melanin During their early development cells have in common the capacity to produce substances such as glycogen and protein The formation of all these end-products depends upon the reaction of specific enzymes with their substrates Such enzymically catalysed syntheses usually occur in soluble extracts and homogenates which do not contain intact cells The formation of cellular end-products also is controlled by hormones that require a high degree of cellular organization in order to function Although the synthesis of a cell's products is regulated by both enzymic and hormonal reactions, these reactions are not related directly to one another The hormones

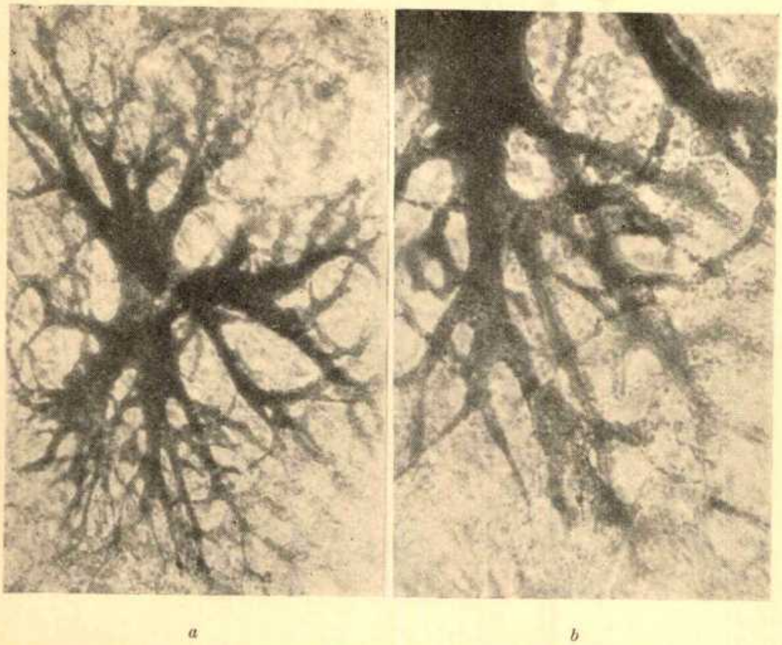

Fig. 1. The pigment granules in a frog's melanocyte can be dispersed throughout the cell as shown above (*a*, × *c*. 320 ; *b*, × *c*. 720) by keeping the cell in solutions of either low osmotic activity, low pH or relatively high potassium and low sodium ion concentration. α- and β- melanocyte-stimulating hormone and adrenocorticotrophic hormone and caffeine also caused dispersion of granules. While these physical and chemical factors produce the same end effect, namely dispersion of granules within the cell, they do so through different mechanisms (see Figs. 3 and 4). At × 720 magnification the melanin granules are seen easily

react with the intact cell to initiate a series of reactions, none of which need be enzymic, that result in a re-location of enzymically active particles. Afterwards, the enzymic reactions concerned with the formation of various cell products also are affected. The nature of the first reaction of the hormone with the cell is still unknown. It may involve a specific interaction between the hormone, cytoplasmic structural proteins, ions and water to change the colloidal state of parts of the cell.

In this article I wish to show that the melanin pigment forming cell, the melanocyte, must be intact if hormones are to affect the rate of melanin synthesis. Initially, hormones do not affect the tyrosinase-catalysed conversion of tyrosine to melanin. Instead they produce a change in the location of enzymically active particles which is followed by a change in the rate of enzymic reactions forming melanin. If hormones were added to tissue extracts without intact cells, no effect on melanin synthesis would be observed. A similar mechanism may apply to the action of hormones on cells other than melanocytes.

What makes the melanocyte a unique cell in which to study the action of hormones is that it contains enzymic particles made dark by melanin. Hence, these particles are readily visible. Of course, it cannot be assumed that a hormone like adrenocorticotrophic hormone acts on the melanocyte in the same way as it does on the fibroblast. Nevertheless, the studies with melanocytes are reasonably clear-cut and must be acknowledged. Perhaps at a later date techniques will be made available to facilitate similar observations on other cells.

Melanocytes resemble nerve cells. Embryologically they are derived from the neural crest. The pigment melanin is made in the cytoplasm of the melanocyte by the reaction of tyrosine with oxygen and tyrosinase. Ordinarily this reaction occurs on cytoplasmic particles that contain not only tyrosinase activity but that of other enzymes as well. For example, the tyrosinase particles from mouse melanoma also possess cytochrome oxidase and succinic dehydrogenase activities. The melanin formed is normally attached to these particles—thus the particles are visible. These particles are called melanin granules or pigment granules and are considered to be mitochondrial structures[1].

It is easy to show that some physical and chemical factors induce clumping of melanin granules about the centre of the cell while others cause dispersion of these granules in the cytoplasm away from the centre

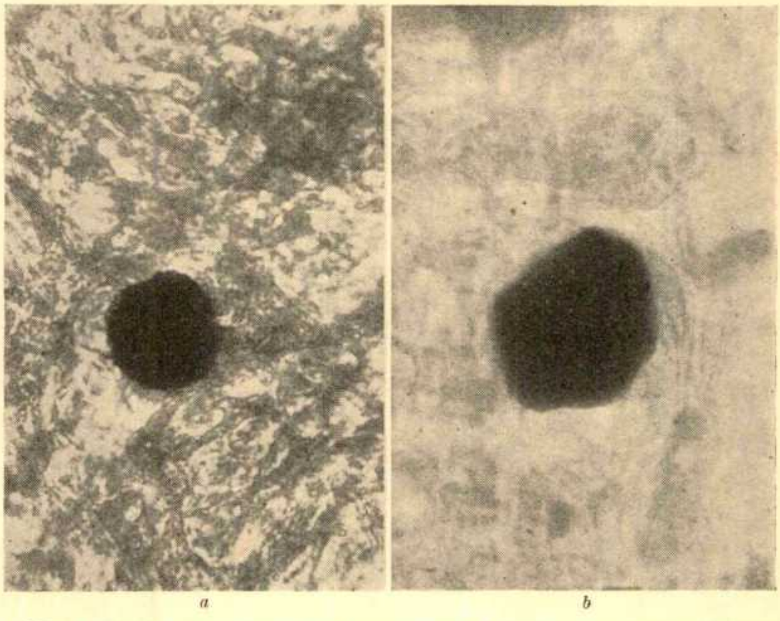

Fig. 2. The pigment cell above is the same kind as that in Fig. 1 except that the cytoplasmic granules are aggregated about the nucleus instead of dispersed throughout the cell (*a*, × *c*. 320 ; *b*, × *c*. 720). The outer borders of the cell, although not shown in this preparation, are the same as in Fig. 1. Aggregation of granules can be induced by placing the cell in solutions of either high osmotic activity, high pH or relatively low potassium and high sodium ion concentration. Melatonin, adrenaline, noradrenaline, acetylcholine, hydrocortisone, serotonin and triiodothyronine also produce aggregation of granules. As in the case of dispersion of pigment granules, aggregation is caused by many factors, all of which produce the same end result but operate through different means (see Figs. 3 and 4)

of the cell. When frog melanocytes are placed in solutions of low osmotic activity or low pH, the granules disperse[2]. A similar effect is achieved by changing the cations in the solution from sodium to potassium. A substance like adenosine triphosphate, which may not even enter the cell, also causes dispersion of the granules. Experiments with frog and fish melanocytes indicate that for the dispersion effect to occur the cytoplasm changes from a gel to a sol and oxygen is utilized. One of the most surprising findings associated with this reversible dispersion reaction is that minute quantities of certain hormones can bring it about. The melanocyte-stimulating hormones from hog pituitary gland, α- and β-hormones, produce darkening in concentrations of 1×10^{-11} M and 2×10^{-11} M, respectively[3,4]. Hog adrenocorticotrophic hormone is effective at 3×10^{-10} M. These three peptides have related amino-acid sequences in their structure[5]. Other dispersing agents include progesterone, caffeine, marsilid and mesantoin. However, when compared with α- and β-melanocyte-stimutating hormones and adrenocorticotrophic hormone, huge quantities are required. Melanocyte-stimulating hormone in high concentrations has no effect on the tyrosine-tyrosinase reaction *in vitro*.

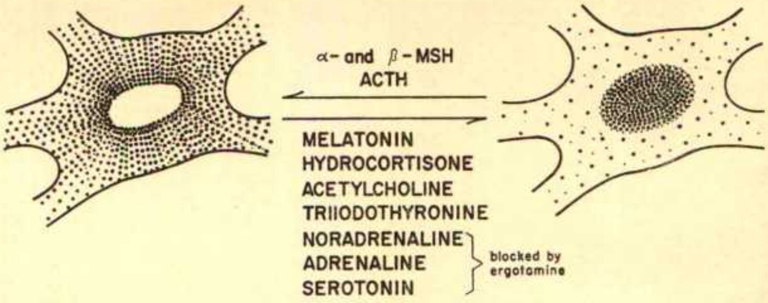

Fig. 3. α- and β-melanocyte-stimulating hormone and adrenocorticotrophic hormone can produce dispersion of pigment granules in the melanocyte. This action can be reversed by the seven compounds listed above. The action of adrenaline, noradrenaline and serotonin but not that of the other aggregating agents can be blocked by ergotamine

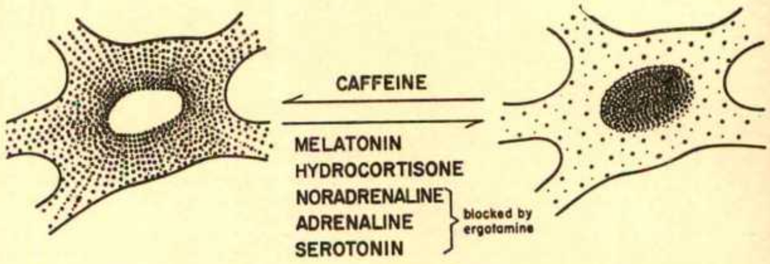

Fig. 4. Caffeine, like α- and β-melanocyte-stimulating hormones and adrenocorticotrophic hormone, causes dispersion of granules in the melanocytes. However, this effect is reversed by melatonin, adrenaline, noradrenaline and serotonin but not by triiodothyronine, acetylcholine or hydrocortisone. The action of adrenaline, noradrenaline and serotonin but not that of melatonin and hydrocortisone can be reversed by ergotamine. Melatonin and hydrocortisone are the only substances known that not only cause aggregation of granules in cells previously darkened by α- and β-melanocyte-stimulating hormone, adrenocorticotrophic hormone or caffeine but also cannot be blocked by ergotamine. However, the action of melatonin and hydrocortisone is not the same. Hydrocortisone acts for only a period of several minutes whereas melatonin has a prolonged action

Aggregation of pigment granules in frog melanocytes occurs in solutions of high osmotic activity or high pH. Replacing potassium by sodium ions in the solution results in a similar effect. Results of work on frog and fish indicate that for the aggregation reaction to occur the cytoplasm must change from a sol to a gel. Oxygen is not required. Potent aggregating agents for frog melanocytes include melatonin, noradrenaline, adrenaline, acetylcholine, hydrocortisone, triiodothyronine and serotonin[6,7]. The molar concentrations of these hormones required for the reaction to occur are 5×10^{-12}, 6×10^{-7}, 6×10^{-7}, 4×10^{-7}, 6×10^{-7}, 8×10^{-7} and 3×10^{-6}, respectively[3].

What happens to the melanocyte when the granules are kept in the dispersed or aggregated state ? In the case of melanocytes from hamster melanoma, injection of melanocyte-stimulating hormone into the animal results in an increase in melanin content of the tumour whereas injection of melatonin results in a decrease in melanin content[8]. Also, injection of melatonin into frogs results in decreased melanin in the skin[9]. Thus in this case, by dispersing tyrosinase, melanocyte-stimulating hormone can bring about more melanin formation. Melatonin, on the other hand, presumably by aggregating the tyrosinase-containing particles, decreases the formation of melanin. In both cases the effect of the hormones on melanin formation is indirect, operating through their influence on tyrosinase location and activity. The activity of the enzyme could well be related to its location within the cell. As suggested earlier, the direct reaction between a hormone and the melanocyte may involve only a relatively specific reaction between hormone, cytoplasmic structural proteins, ions and water to change the colloidal state of parts of the cell[10]. This change in colloidal state eventually would affect the tyrosine-tyrosinase reaction.

The question arises as to whether or not the effect of hormones on the movement of cytoplasmic particles is peculiar to melanocytes or occurs in other cells as well. In this regard it is of interest that adrenocorticotrophic hormone, cortisone and hydrocortisone affect the structure of mast cells[11]. The latter become vacuolated, diminish in size and acquire irregular outlines. Cytoplasmic granules clump together to form aggregates. Cortisone and hydrocortisone induce the formation of cytoplasmic vacuoles in fibroblasts grown in tissue culture. Hydrocortisone also reduces the amount of collagen formed in cultures of fibroblasts.

What I want to emphasize here is that the experiments with melanocytes 'prove' that the intact cell is necessary for the action of a hormone, when action is used in the sense of controlling the end function for which the cell is known, for example, melanin formation in the case of the melanocyte. To change the rate of melanin formation the hormone exerts an indirect effect on the tyrosine-tyrosinase reaction. It is not possible to demonstrate a direct hormonal effect on this reaction. This situation is somewhat analogous to some of the old problems of mathematics. For years attempts had been made to trisect an angle or square a circle with only a pencil, straight edge and compass, or to find a formula to solve equations of the 5th order. However, in fairly recent times it has been shown clearly that these problems cannot be solved in a strict sense. Only approximations are possible. In biology, unlike mathematics, clear-cut proofs are hard to come by. But the experiments carried out by many investigators suggest the conclusion that it is essential for the cell or organized cell unit to be intact in order that a hormone may exert its effect.

[1] (a) Woods, M. W., and Hunter, J. C., "Pigment Cell Biology", 455 (Academic Press, N.Y., 1959). (b) Hochstein, P., *ibid.*, 455.

[2] Lerner, A. B., and Takahashi, Y., "Recent Progress in Hormone Research", 12, 303 (1956).

[3] Lerner, A. B., and Case, J. D., *J. Invest. Derm.*, **32**, 212 (1959).

[4] Lee, T. H., and Lerner, A. B., *J. Biol. Chem.*, **221**, 943 (1956).

[5] (a) Harris, J. I., and Lerner, A. B., *Nature*, **179**, 1346 (1957). (b) Harris, J. I., *Biochem. J.*, **71**, 451 (1959).

[6] Lerner, A. B., Case, J. D., Takahashi, Y., Lee, T. H., and Mori, W., *J. Amer. Chem. Soc.*, **80**, 2587 (1958).

[7] Wright, M. R., and Lerner, A. B. (to be published).

[8] Foster, M., "Pigment Cell Biology", 301 (Academic Press, N.Y., 1959).

[9] Foster, M., Takahashi, Y., and Mori, W. (to be published).

[10] Klotz, I. M., *Science*, **128**, 815 (1958).

[11] Asboe-Hansen, G., *Physiol. Rev.*, **38**, 446 (1958).

THE NUCLEAR-POWERED SHIP, *SAVANNAH*

THE marine world has become accustomed to the reality of nuclear-powered ships through the widely publicized performances of the American submarines *Nautilus* and *Skate* and the building of the Russian icebreaker *Lenin*. These are specialist craft in which the economics, conveniences and safety precautions pertinent to merchant shipping play no part. To test the possibilities of the application of nuclear power to a vessel normally carrying passengers and a mixed cargo the nuclear-powered ship *Savannah*, named after the first steamship to cross the Atlantic, is now being built by the New York Shipbuilding Corporation for the U.S. Atomic Energy Commission and the U.S. Department of Commerce. She is specifically designed as a test ship, to obtain information on practical construction and operating technology, though it is realized that at the present stage the ship is not an economic proposition.

The *Savannah* is of 22,000 tons displacement when loaded, nearly 600 ft. in overall length, and draws 29.5 ft.; she has a cargo capacity of 10,000 tons, carries 60 passengers, a crew of 110, can cruise at 21 knots, and is expected to be ready for unrestricted operation by summer 1960. Externally, the design appears advanced and pleasingly simple. She has sweeping lines with a well-raked stem and cruiser stern. The superstructure incorporating the bridge and sheltered decks is placed well aft, with four holds forward of the bridge. Passenger accommodation is conventionally luxurious, while cargo-handling equipment is of the most advanced and fastest type.

The propulsion plant normally develops 20,000 s.h.p. absorbed by a single screw. The pressurized water reactor, the type used in the *Nautilus*, is fuelled by uranium oxide with about 4.4 per cent enrichment of uranium-235, clad in stainless steel rods, and cooled by light water at a pressure of 1,750 lb./sq. in., heat being abstracted from the core by a three-pass flow arrangement. Emphasis has been placed on the necessity for a long lifetime of the core, the design target being 52,000 MW. days or 3½ yr. under normal operating conditions; a large low-density core is therefore used, while the use of uranium-235 as a fertile material is expected to extend the life of the core through its conversion to plutonium. The variation of power output demanded from the bridge can be met by automatic operation of the boron – stainless steel control-rods.

At normal load the inlet temperature of the primary coolant, demineralized water flowing through two closed loops, is 494.7° F. and the outlet temperature 521.3° F., the coolant being circulated by four pumps and the heat supplied by the reactor rejected to the secondary circuit steam generators. The primary water is continually purified to remove corrosion, fuel and fission products.

The heat rejected by the primary coolant is used to generate steam in the secondary circuit from two generators which supply dry saturated steam at 490 lb./sq. in. to high- and low-pressure De Laval turbines driving the main shaft through a double reduction gear. Two 1,500-kW. steam-turbine generators provide power for auxiliary services and a low-pressure heat exchanger provides steam for hotel services and space heating. For emergency two 750-kW. diesel-driven generators provide power for removal of reactor heat after shut-down and will supply essential services, including the take-home motor coupled to the main shaft.

The installation of nuclear power plants in merchant shipping presents grave problems of ensuring the complete safety not only of both passengers and crew, but also of the inhabitants of the ports of call. It is not sufficient to guard against the hazard of a major explosion. Complete precautions must also be taken against the possibility of irradiation caused by collision or by the sinking of the ship in shallow water. Safety considerations have been elaborate on the *Savannah*. The design of the hull is such that the ship will remain afloat with two of the eleven main compartments flooded: this is not an abnormal requirement, but in the *Savannah* elaborate collision bulkheads and collision mats ensure that a ramming ship would have to penetrate 17 ft. of stiffened ship structure before the containing vessel of the reactor was affected. The inner bottom below the reactor is also strengthened by transverse and longitudinal members to form an 'egg crate' construction. It is estimated that the reactor compartment is impervious to any collision with all but 1 per cent of the world's mercantile marine; the likelihood of high-speed collision in harbour waters is considered negligible.

The chief radiation sources are the reactor core and the primary coolant. The reactor is shielded by a lead-covered steel tank which surrounds the reactor with an annular water space. It is estimated that the dose-rate outside the primary shielding will not exceed 200 mr. per hr. 30 min. after shut down. This rate is low enough to permit approach for inspection and maintenance. The whole of the primary system is further surrounded by a containing vessel, designed to limit the radiation in the holds to 5 r. a year and to 0.5 r. a year in the passenger spaces. The containing vessel, cylindrical in shape, 35 ft. in diameter by 50.5 ft. long, also serves to prevent spread of radioactivity in the event of any rupture of the primary system The lower half of this vessel is of concrete surrounded by water tanks, while the upper half is of lead slabs surrounded by polyethylene Should the ship sink in deep water, two of the manholes will open automatically to equalize pressure and then close to prevent undue leakage of radiation products Provision is also made in the case of shallow-water sinking to allow purging of the containing vessel or filling it with concrete The total weight of the containing vessel is about 2,000 tons

Waste liquids likely to be radioactive are fed to storage tanks and will not be discharged at sea except under the conditions set forth by the Maritime Administration and the Atomic Energy Commission Radioactive gases are diluted and discharged up the radio mast after being filtered Purging of the air of the containing vessel, of which the argon is slightly radioactive, is carried out periodically at sea Cooling of such components as primary circulating pumps is effected by fresh water cooled by sea water in an intermediate circuit The sea water does not become radioactive

Apart from the care taken in the design and construction of the ship, extensive training in nuclear reactor theory and its marine application is being undertaken by the candidates for the posts in the *Savannah* The longest course taken by engineering-officer candidates occupies fifteen months A shorter course has also been arranged and is intended for candidates already possessing a science degree and includes seven observers from Britain, Denmark, Holland and Japan

F D ROBINSON

OBITUARY

Sir Alfred Egerton, F R S

ALFRED CHARLES GLYN EGERTON died suddenly on September 7 following a heart attack He was on holiday at the time at his house at Mouans Sartoux in the south of France, with his wife and son Francis He was seventy-two, but was in full vigour, his sudden death comes as a great blow to all those in combustion science, in which Sir Alfred has been the acknowledged leader for many years He had also made many important contributions in engineering, and in scientific administration and education

He was educated at Eton, where he took the science prize and founded the College Scientific Society, and at University College, London, where he gained first-class honours in chemistry and was later president of the College Chemical and Physical Society He studied at Nancy and in Berlin with Prof W Nernst, and in Sir William Ramsay's private laboratory as his last research student During 1909–13, he was instructor at the Royal Military College and, during the First World War, carried out research on explosives and had his first contact with chemical engineering

After the War Egerton went to the Clarendon Laboratory at Oxford and carried out researches on the vapour pressures of metals at high temperatures and, in advance of his time, worked on the separation of zinc isotopes He was appointed reader in thermodynamics in 1923 During a British Association meeting in Canada, Sir Harry Ricardo and Sir Henry Tizard, with whom his friendship was life-long, aroused his interest in combustion and in the role of the newly discovered 'anti-knocks' He applied his knowledge of physical chemistry to this problem of knock in internal combustion engines and put forward the view that break-down of unstable organic peroxides was responsible for 'pre-sensitizing' the premature detonation His interest in combustion continued throughout his life, and he and his research group published a steady stream of valuable papers on the role of peroxides in combustion, on peroxide analysis, on slow combustion processes, on gaseous detonation, on limits of inflammability, on burning velocities, and on techniques for these studies, such as the use of absorption spectra and the development of the flat-flame burner

Egerton also carried out or stimulated work in many fields of applied science He made measurements of the properties of that important working substance steam, and stressed the value of methane or natural gas as potentially the most efficient fuel for the internal combustion engine, and worked on the combustion, liquefaction and bulk handling of methane This led to an interest in liquefaction problems, and he was active in founding the Low Temperature Group of the Physical Society, of which he was first chairman in 1946

He was elected to the Royal Society in 1926, and in 1936 was appointed professor of chemical technology in the Imperial College of Science and Technology (University of London), a position which he held until his retirement in 1952 During his tenure of the chair, he started the undergraduate course in chemical engineering and pioneered the development of this subject in Great Britain The Department, under his guidance, became a leading centre in both combustion research and chemical engineering

Egerton was secretary (physical sciences) of the Royal Society during 1938–48, during the important War period, and he was also a member of the Scientific Advisory Committee of the War Cabinet during 1940–45 In 1942, he spent some time in Washington in charge of the British Commonwealth Scientific Office, where he did important work improving Anglo-American co-operation His membership of numerous committees gave him a tremendous breadth of knowledge of affairs and of people At various times he was chairman of the following committees the Heating and Ventilating Committee, the Fuels and Propulsion Committee, Admiralty Scientific Research Department, the Scientific Advisory Council, Ministry of Fuel and Power, the committees reporting to the Government of India on the Indian Institute of Science, and on the sixteen Government of India laboratories, the Scientific Advisory Committee of the British Council, the Combustion and Fuels Committee of the Aeronautical Research Council, and the Royal Society Scientific Information Conference He had been director of the Salters' Institute of Industrial Chemistry and a manager of the Royal Institution He was president of the British Section of the Combustion

Institute, editor of *Combustion and Flame*, and formerly of *Fuel* He was active in work on the dissemination of scientific information (*Science Abstracts* Committee), on the use of scientific man-power (Barlow Committee) and on the use of the world's fuel and energy resources His educational interests are shown by his active membership of the governing bodies of Winchester College and of Charterhouse Last year, he was responsible for the successful organization of the seventh International Combustion Symposium in Oxford His recent intense activity had been on the Government Committee of Inquiry into the Fishing Industry, and in research into the characteristics of smouldering for the Tobacco Manufacturers' Standing Committee His work was recognized by a knighthood in 1943 and a number of honorary degrees and medals, including the Rumford Medal of the Royal Society in 1946

In 1912, he married the Hon Ruth Cripps, only daughter of the first Baron Parmoor, sister of his close friend at University College, the late Sir Stafford Cripps

As a man, we remember his quiet unassuming manner, his unfailing smile of greeting, his tireless work on his many scientific interests, and his delight in his second career as a painter Somehow, despite his many activities, he always had time to spare for everyone He had the genius for bringing out the best in those with whom he worked and took a fatherly interest in the numerous research students he sponsored, so many of them now in high positions in science and industry This keen personal interest in his students, colleagues, and indeed in all he did, was fully shared by Lady Egerton His life and work are an example to all those whom he has influenced

A G Gaydon

NEWS and VIEWS

Biochemistry at Birmingham Dr S V Perry

The development of a Department of Biochemistry in the University of Birmingham, arising as it does in part from the former Department of Industrial Fermentation, needs for guidance a man of scientific ability and vigorous powers of leadership The appointment of Dr S V Perry to be professor of biochemistry has recently been announced Dr Perry graduated with first-class honours in biochemistry in the University of Liverpool in 1939 and was elected to the Isaac Roberts research scholarship upon graduation After the Second World War he was elected a Rouse Ball research student of Trinity College, Cambridge, and began his researches on muscle biochemistry in the Department of Biochemistry He was elected a research fellow of Trinity College, Cambridge, in 1947 and a Commonwealth Fund Travelling Fellow in 1948, spending the year 1948–49 in the Department of Physiology of the Medical School of the University of Rochester, New York, investigating the biochemical properties of skeletal muscle In 1950 he was appointed a lecturer in biochemistry in the University of Cambridge His researches have been largely concerned with biochemical function in relation to intracellular morphology with particular reference to the muscle cell A study of the intracellular components of striated muscle has been pursued in an investigation of the biochemistry of the cell in general, and of the contractile process in particular These studies are throwing important light on the nature of the association between muscle proteins and the role of their interaction in muscular contraction Dr Perry has taken part, by invitation, in a number of international congresses concerned with the biochemistry of muscle, and has published many articles on this subject in the *Biochemical Journal* and other scientific periodicals

Analytical Chemistry at Birmingham

Prof Ronald Belcher

The award of the title of professor of analytical chemistry is a tribute to the work Dr Belcher has done at Birmingham in building up the School of Analytical Chemistry, which is unique in Great Britain The honour comes at an appropriate time, since he is at present the president of the Analytical Chemistry Section of the International Union of Chemistry and a vice-president of the Union Prof Belcher received his early education in Sheffield and gained his first qualifications through the Royal Institute of Chemistry After carrying out extensive researches since 1928 on coal at the University of Sheffield, he became a lecturer in chemistry in the University of Aberdeen in 1946, moving to Birmingham in 1948 Since that time a constant flow of papers has come from his group and no less than twenty-eight higher degrees have been awarded to graduates in analytical chemistry under his supervision With pupils and colleagues he has published more than 150 papers and ten well-known books, all in the field of analytical chemistry, and to these and his many editorial and committee activities he owes his world-wide reputation He gained the Ph D and D Sc of the University of Birmingham With the vast extensions of the Chemistry Department at Birmingham nearing completion, Prof Belcher and his colleagues will have greatly increased facilities for research and the training of analysts at all levels

Mathematical Physics at Birmingham

Prof G E Brown

The title of professor of mathematical physics has been conferred on Dr G E Brown, at present reader in the Department of Mathematical Physics Dr Brown, who is a citizen of the United States, studied in South Dakota State College, at the Universities of Iowa and Wisconsin, and after war service became a graduate student at Yale in 1947 and obtained his Ph D there in 1950 He was awarded the D Sc of the University of Birmingham in 1957 He went to Birmingham with a post-doctoral award in 1950, was appointed a research fellow in September 1950 and has been on the teaching staff since 1954, except for a period of study leave from January to September 1958, which was spent in the Institute for Theoretical Physics in Copenhagen He has published numerous papers on different aspects of quantum theory, particularly on relativistic electron theory, including relativistic corrections in atomic problems More recently he has done important work in nuclear theory, including a series of papers with various collaborators on the relation between the nuclear many-body problem and the 'optical model'

National Science Foundation

Dr David D Keck

THE National Science Foundation has announced that Dr David D Keck has resigned his position at the New York Botanical Garden in order to remain permanently as programme director for systematic biology at the Foundation's Division of Biological and Medical Sciences The Systematic Biology Programme receives research proposals and administers more than three hundred active grants In 1950, Dr Keck joined the staff of the New York Botanical Garden as head curator, he became assistant director in 1955 and served as acting director in 1958 From 1926 until 1950 he was on the staff of the Division of Plant Biology of the Carnegie Institution of Washington, at Stanford, California There he was a member of a research team concerned with pioneer work on the nature of plant species He is the author of many technical papers and has collaborated with Philip A Munz in writing "A California Flora" that has just come from the University of California Press

Microbiological Research

IN a written answer in the House of Commons on July 21, Mr H Nicholls, Parliamentary Secretary to the Ministry of Works, stated that since the Council for Scientific and Industrial Research announced last December its intention to encourage university research in microbiology, ten applications had been received for grants for research projects in microbiology not previously supported by the Department of Scientific and Industrial Research and all these applications had been approved

Zenith Reactor

A QUESTION was asked in the House of Lords on July 15 about the 'Zenith' low-power reactor installed at Winfrith Heath mainly to further the work of the European Nuclear Energy Authority project for research on a high-temperature gas-cooled reactor In reply, the Minister of Power, Lord Mills, said that the project would pay rent to the Atomic Energy Authority for the use of the reactor It was hoped that about half the professional staff would be provided from signatory countries other than the United Kingdom Of the total estimated cost of the project, £10 million would be contributed by the participants, the United Kingdom supplying the balance of £3 6 million and would retain ownership of the reactor and other equipment in Britain when the project was terminated The work would be carried out by the Atomic Energy Authority, but all participating countries had their say on various matters connected with the project

Chief Inspector of Nuclear Installations

IN the course of the debate in the House of Commons on July 2, when the Nuclear Installations (Licensing and Insurance) Bill was given its third reading, it was stated that the Minister of Power intended to appoint a chief inspector of nuclear installations who would be responsible for advising on the measures to be taken to carry out the Minister's responsibilities under the Act The appointment had been offered (pending the Royal Assent) to Major-General S W Joslin, who had accepted it Major-General Stanley William Joslin was educated at Hackney Downs School, Royal Military Academy, Woolwich, and the University of Cambridge He held the appointment of director of mechanical engineering at the War Office, until he joined the United Kingdom Atomic Energy Authority in 1954, and later became deputy director (personnel) of the Industrial Group As chief inspector, Major-General Joslin will be the head of the inspectorate, and one of his main tasks will be to advise on the organization and build-up of the inspectorate

Exchanges between Soviet and U S Scientists

THE U S National Academy of Sciences and the U S S R Academy of Sciences have announced the signing of a two-year agreement providing for exchange visits by research scientists of each country for periods up to one year Under the terms of the agreement, each Academy named twenty fields of specialized scientific inquiry in which its scientists wish to observe or conduct research within the host country In addition, the agreement provides that the two Academies will organize joint symposia dealing with scientific problems of current interest, assist each other in the exchange of scientific information, and on a reciprocal basis exchange invitations to important scientific meetings Implementation of these provisions will substantially increase the exchange of scientists between the two countries

Colonial Development

THE annual report of the Colonial Development Corporation for 1958 (London H M Stationery Office Pp v+69 4*s* 6*d* net) and the last over the signature of Lord Reith, who was succeeded as chairman on March 31 by Sir Nutcombe Hume, records 77 continuing projects compared with 76 the previous year Four have stopped, and of the five new projects approved, one, Federation Chemicals, Ltd (Trinidad), for the first time associates Corporation money with American technique and finance in a Colonial territory Much effort has been spent in Nigeria in seeking to bring about joint development companies in partnership with regional Governments, and it is understood that the Corporation's view that such companies have a particular importance as instruments through which Nigerians and the Corporation can share responsibility in investigating and launching development projects will be accepted Capital approved for new projects and for expansion and completion of existing ones amounted to £3 million compared with £6 million in 1957, and gross new expenditure was £6 million The report claims that the work of the Corporation has increased Colonial production of rice, citrus, pineapples, bananas, palm oil, cocoa, coffee, tea, margarine, flour, meat and fish and also of gold, silver, copper, timber, cement, manila, hemp, wattle extract, rubber, hides, tobacco, tung oil, copra, electricity, houses, factories, roads and bridges Besides assisting in the creation of such productive assets as hydroelectric installations in Dominica, St Vincent, Rhodesia and Kenya, irrigation canals in Swaziland, roads and bridges in Ghana and Nigeria, and in making more than 500,000 acres of idle land productive, direct projects of the Corporation provided employment for more than 16,000 workers

Lord Reith claims, however, that much more could have been done, and while he stresses the need for first-class management and for trusting the Corporation to use its commercial judgment in the best interests of overseas development and thus of Great Britain itself, he is strongly critical of its relations with the Government and of consequent frustration and discouragement possibly due to differences of interpretation of the Overseas Resources Development Act. Lord Reith suggests that a rapid review of the working of that Act might be helpful. He complains particularly of the extent to which applications for projects are held up, apparently through disagreement as to the nature of the work the Corporation should do and the degree of control which the Government should exercise over it. He points out that the restrictions imposed upon the future activities of the Corporation in the emergent territories will deny them the full use of its unique facilities and managerial experience at the critical transitional stage of their development, in spite of the obligation for ensuring continuing development finance in such territories which the Government appeared to recognize at the Montreal Conference.

Chinese Scientific Literature

THE Lending Library Unit of the Department of Scientific and Industrial Research is now issuing a list of current periodicals received from China. The first list (July 1959) gives the titles of one hundred periodicals which are being received regularly, and these publications can be borrowed from the Unit by approved borrowers of the Science Museum Library, provided Science Museum Library loan requisition forms are used. Twenty-one of the periodicals listed are obtained by exchange, and special attention is directed to *Scientia Sinica* (in English) and to *Science Record* (in English, French, German and Russian). The periodicals listed are annotated according to the category of readers for whom they are intended, and whether they include contents lists or abstracts in a Western European language. This first issue also includes a note on the Chinese phonetic alphabet.

Mordell's "Reflections"

CAMBRIDGE mathematicians have sometimes mitigated the austerity of their scholarship on retirement, and to this wise relaxation we owe Hardy's "Apology", Littlewood's "Miscellany" and now Mordell's "Reflections" ("Reflections of a Mathematician", by Prof. L. J. Mordell. Pp. vii+50. Montreal Canadian Mathematical Congress, Chemistry Building, McGill University or École Polytechnique, 2500 Guyard Avenue, 1959. n.p.) In this collection of short, informal essays, the author is primarily interested in explaining the point of view of the professional mathematician to fellow scholars who are not mathematicians. He is not concerned with applications, but with mathematics itself—what it is, the fascination of its æsthetics and its techniques, the difficulties and triumphs of creative work, not without some mild insinuation that the theory of numbers is the crown of mathematics. Two of his points deserve emphasis. The first is that the three cardinal virtues for the young mathematician are faith, hope and curiosity, and that the greatest of these is curiosity. Secondly, he stresses that the mathematician's task is not ended when he has solved his problem; he is under an obligation to his fellow-workers to present his results clearly and intelligibly, and must not allow the economic demand for brevity to result in obscurity. The selection of precisely the right number of steps required to support the argument, so that it shall be neither tedious nor obscure, is a matter to which the young mathematician should pay careful attention. Mordell in this connexion quotes with approval Polya's advice "if you have two things to say, say them one at a time".

Museum of Applied Arts and Sciences, Sydney

THE Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for 1957 (Pp. 20. Sydney Museum of Applied Arts and Sciences, 1959) stresses the great urgency of allocating a site for a new museum. It points out that a modern science museum requires an extensive area and building, not only to preserve and display its national treasures in an appropriate manner, but also to exhibit full-sized engineering exhibits. Within the limits of the resources of the Museum, provision was made to show the advance of science during the International Geophysical Year. Also by means of films, diagrams and models visitors were presented with the development of guided missiles and space satellites. The results of research by the staff in the field of essential oil are drawing increasing numbers of inquiries from all over the world. Since the Museum deals principally with applied science, it was always necessary to strike a balance between pure and applied research by the staff.

Further Botanical Collections

THE great tradition of travelling and collecting plants, which, among others, we associate particularly with the name of Linnaeus and his followers and adherents, is still very much alive in Sweden. A recent issue of the *Arkiv for Botanik* (4, Part 1; 1959; Kungl. Svenska Vetenskaps—Akademien, Stockholm) is of special interest in this connexion in that it contains many new floristic records based on expeditions to places of such unique interest as the Juan Fernandez Islands. Several of the contributions, on Hepaticæ (S. Arnell), Mosses (E. B. Bartram), Uredinales (I. Jørstad), relate to materials chiefly collected in the course of an expedition by the eminent Swedish botanist, Dr. C. Skottsberg, and his wife during 1954–55 to these islands. Some of the records also relate to the Falkland Islands and South America. There is also an account of Annonaceae by von Rob. E. Fries, based on specimens collected by Dr. Eric Asplund during his travels in Ecuador in 1955.

The Ciba Foundation, 1949–59

THE Ciba Foundation, founded in 1947 by the Swiss firm, Ciba, Ltd., of Basle, for the promotion of international co-operation in medical and chemical research, shows in its report for the years 1949–59 a remarkable record of success. Housed at 41 Portland Place, London, W.1, in a building designed by the brothers Adam which was built in 1778, and is now scheduled as a building of historical and architectural interest, the Foundation, through its Trustees, Executive Council and International Scientific Advisory Panel, has arranged numerous international conferences, colloquia and discussion meetings on various subjects, as well as the Ciba Foundation annual lectures and scientific-film sessions (The Ciba Foundation for the Promotion of International Co-operation in Medical and Chemical Research. Ten Years Report for 1949–1959. Pp. 1–64. The Ciba Foundation, 41 Portland Place, London, W.1). A feature of the colloquia and conferences is that they are attended for three or four days by experts in various fields of work from various countries who are invited to take part, the number attending being kept low, great importance being attached to free discussion and social contacts between the participants Other activities of the Foundation are the one-day Study Groups, which are held in honour of overseas members of the Foundation's international scientific advisory panel and similar one-day meetings, or 'Research Fora', which are held on behalf of sponsoring individual or scientific societies The Foundation also provides accommodation and hospitality for various scientific organizations Its Library includes autographed copies of works by distinguished scientific men and tape-recordings of the Foundation's meetings The Foundation, in co-operation with the Institut National d'Hygiène, Paris, offers twelve Anglo-French Medical Exchange Bursaries of £50 a month tax-free for two to four months for the study of special techniques in Great Britain and France A glance through the list given in this report of the subjects discussed at the Foundation's various meetings shows that, although the emphasis has been on endocrinology and problems of ageing, these discussions have dealt with many of the most important lines of modern medical research Results have been published in some forty-seven volumes issued by Messrs J and A Churchill, London

Oreopithecus

Since the discovery in 1872 of the lower jaw of the fossil primate *Oreopithecus* in lignite deposits in Italy, conflicting views have been expressed by various authorities on its taxonomic status, but in general there has been in the past a consensus of opinion that it represents an aberrant type of cercopithecoid monkey, showing in its dentition some approximation to the anthropoid apes The discovery in recent years by Dr J Hurzeler, of the Basle Museum, of many more specimens of this Lower Pliocene primate, including the skull and much of the post-cranial skeleton, has lent some support to the contention that it is more closely related to the anthropoid apes But Dr Hurzeler goes further than this, and has argued that the dentition and skeleton show some hominid features which suggest that *Oreopithecus* is properly to be regarded as a Pliocene representative of the very base of the hominid stem In a careful study of a maxilla with the upper dentition in the British Museum by P M Butler and J R E Mills (Bulletin of the British Museum (Natural History) Geology Vol 4, No 1 A Contribution to the Odontology of *Oreopithecus* Pp 1–26+plate 1 London British Museum (Natural History), 1959 10*s*), the authors adduce strong reasons for affinities with the anthropoid ape family but find no good evidence for a hominid relationship They regard such 'hominid' features of the dentition as have been described as probably the result of parallel evolution associated with the abbreviation of the facial skeleton and a reduction in size of the canine teeth They conclude that *Oreopithecus* should be retained in a separate family, Oreopithecidae, as originally maintained by Schwalbe (1916), and that it is probably a representative of a phyletic line which developed independently of the evolution of the modern anthropoid apes or the Hominidae The material collected by Dr Hurzeler still more recently may perhaps lead to a modification of this point of view, for according to an article which appeared in *Antiquity* (33, 131 , 1959) it is stated "on information received"—but not yet published—that the post-cranial skeleton shows some clearly marked anthropoid ape features combined with a few which could be regarded as hominid characters But a final decision on the status of *Oreopithecus* will no doubt depend on how far it is possible to make correction for the distortion by crushing which has evidently affected much of the fossil material

Floral Abnormalities in Broccoli

D R Sampson and M MacArthur have described some interesting floral abnormalities which apparently arise spontaneously in green sprouting broccoli (*Annals of Botany*, N S , 23, 211, 1959) Of the several types of abnormalities that may develop in a raceme, flowers with united sepals bearing ovules ventrally on placentae along the lines of sepal union, and pads of stigmatic tissue at the apices of the sepals, are among the most conspicuous Other curious developments include open, boat-shaped gynœcia, and irregular terminal structures suggestive of laterally united gynœcia Developmental aspects are discussed and some of their morphogenetic implications noted

Nitrate Reductase from Germinating Wheat Embryos

The isolation and purification of a soluble enzyme, a nitrate reductase, from embryos of germinating wheat have been described by D Spencer (*Australian J Biol Sci* , 12, 2, 181, 1959) This enzyme is coupled specifically to reduced diphosphopyridine nucleotide Addition of flavin adenine dinucleotide to the purified enzyme results in a threefold increase in activity Flavin mononucleotide is without effect Potassium cyanide and sodium azide cause 50 per cent inhibition of enzyme activity at 1 $6 \times 10^{-6} M$ and $2 \times 10^{-5} M$ respectively The effect of a range of other inhibitors is reported The presence of inorganic phosphate is required for maximum activity The dissociation constant (K_S) of the nitrate–enzyme complex is 3 8×10^{-4} M, and that of the diphosphopyridine nucleotide–enzyme complex is 8×10^{-6} M The pH optimum for enzymatic activity is 7 4

Climatic Changes and Secular Solar Activity

The Geophysical Institute of the Czechoslovakian Academy of Sciences has published a paper by Z Gregor and L Křivský on the long-duration changes in the climate of the Atlantic-European area as related to the secular solar activity (*Geophysical Sbornik*, No 62 1957 Russian texts, Czech and German summaries) These climatic changes, expressed by the circulation of the atmosphere and the movement of the frontal zone, lead to an increase of the average temperature in this area, and promote the recession of glaciers The changes are attributed to the secular changes in the emission of solar energy

Infra-red Absorption Bands

The measurement of the intensity of infra-red absorption bands is important both in theory for the deduction of bond moments and hence structural studies, and in practice because it is the basis of quantitative analysis by infra-red methods Until about 1946 the subject was comparatively neglected because of the scarcity of reliable instruments, but since then a considerable literature on the subject has been built up and the bibliography compiled by R G Gillis (*Australian Defence Standards Laboratories Technical Memorandum* 2 The Intensity of Infra-red Absorption Bands a Bibliography Compiled by

Dr R G Gillis Pp i + 48 Maribyrnong, Victoria Defence Standards Laboratories, Department of Supply, 1958), covering work up to the end of 1957, should be most valuable 134 references on the theory and application of intensity measurements contained in *Chemical Abstracts* are collected together with their abstracts They are arranged substantially in chronological order within the thirteen sections entitled early work (pre-1946) , general (theory) , general (experimental) , simple molecules , C—H and C—D bands , hydrocarbon analysis , O—H and O—D bands , N—H and N—D bands , ester and ketone C = O bands , steroids , C ≡ N bands , pressure broadening , and pressure-induced absorption Since the principles of quantitative analysis are now well known, references to many methods for the quantitative determination of particular compounds have been specifically omitted from the bibliography

*p*H Measurements

ANALYTICAL MEASUREMENTS, LTD , Richmond, Surrey, is supplying an analytical pocket *p*H meter which can be used to make *p*H measurements with small amounts of solution. It is complete with batteries and a case of plastic tubes of buffer solution The meter has a scale from 0 to 14 *p*H and an accuracy of 0 1 *p*H is obtainable The assembly is in a waterproof case , the electrometer tube, switch and input connector are sealed in a single unit and the weight with accessories is only 3 lb The current price is £39 18*s*

Shell Chemical Co Reorganization

CERTAIN of the operations of the Shell Chemical Co , Ltd , are to be integrated into three divisions corresponding to the three main fields in which it is engaged, namely, industrial chemicals, agriculture and plastics These changes became effective on July 1 The manager of the Industrial Chemicals Division is Mr P J March This Division deals with solvents, general chemicals, resins and detergent products The existing agricultural organization remains unchanged as the Agricultural Division under Mr H G Huckle The Plastics Division has assumed responsibility for polyolefins, polystyrene, polyvinyl chloride and synthetic rubber The manager of this Division is Mr V N Luke

Rare Earth Metals

SUCCESSFUL production of all the rare earth metals has been achieved by Johnson, Matthev and Co , Ltd , following some active research over the past few years Supplies of the rare earths in their normal form as oxides have been available in several grades of purity , however, improved techniques for the production of the metallic elements have now been brought to fruition, and all the fourteen naturally occurring elements, together with the closely related elements scandium and yttrium, are now available in a variety of forms The metals are reduced from their fluorides with lithium, calcium or lanthanum in tantalum crucibles in an atmosphere of argon, and are then re-melted in vacuum Impurities are held at a very low level and in some cases the purity is higher than has hitherto been achieved

Society for Applied Bacteriology

AT the annual meeting of the Society for Applied Bacteriology, held in London on July 8, the following were confirmed in office *Hon President,* Mr D A McKenzie , *Hon Treasurer,* Mr G Elis Jones , *Hon Editors,* Dr S E Jacobs and Dr C A E Briggs , *Hon. Publications Manager,* Mr A H Walters ; *Hon Advertising Manager,* Mr E J Mann , *Members of Committee,* Dr Eve Billing, Mr N J Butler, Prof E L Crossley, Dr J G Davis, Mr B M Gibbs, Mr D J Jayne-Williams, Dr Jane Meiklejohn, Dr G C Ware and Dr M Woodbine After eight years as hon secretary of the Society, Mr G Sykes announced his resignation His place will be taken by Dr Ella M Barnes, Low Temperature Research Station, Downing Street, Cambridge This change will take place towards the end of October

Josiah Macy, Jr , Foundation Grants

UNRESTRICTED grants amounting to 1,650,000 dollars to eleven private medical schools in support of their teaching research staff have been announced by the Josiah Macy, Jr Foundation, New York The Foundation has made unrestricted grants of 50,000 dollars per annum for a three-year period to each of eleven private medical schools for strengthening their research teaching staff, particularly in the medical science departments

National Science Foundation Grants

THE National Science Foundation of the United States has announced the award of fourteen grants totalling 1,534,500 dollars The aim is to strengthen biological research by helping to provide scientists with new or modernized facilities and specialized experimental equipment Major grants are to be awarded as follows 250,000 dollars to the Woods Hole Oceanographic Institute, Massachusetts , 171,600 dollars to the Bernice P Bishop Museum, Hawaii ; 162,000 dollars to the Marine Laboratory, University of Miami , 155,000 dollars to the California Institute of Technology , 150,000 dollars to the University of Chicago , 135,000 dollars to the Long Island Biological Association , and 105,000 dollars to the Woods Hole Marine Biological Laboratory Other recipients are · White Mountain Research Station, University of California , California Academy of Sciences , Colorado State University , University of Chicago ; University of Missouri , Marine Laboratory, Duke University, North Carolina , and the Academy of Natural Sciences of Philadelphia

The Alvarenga Prize

ON July 14 the College of Physicians of Philadelphia awarded the Alvarenga Prize for 1959 to Dr Hilary Koprowski, professor of research medicine, University of Pennsylvania, for his outstanding work on the development of a living attenuated virus vaccine against poliomyelitis The Alvarenga Prize was established by the will of Pedro Francisco DaCosta Alvarenga, of Lisbon, Portugal, an associate fellow of the College of Physicians of Philadelphia, to be awarded annually by the College of Physicians on the anniversary of the death of the testator, July 14, 1883

Carlsberg-Wellcome Travelling Research Fellowships

THE Carlsberg Foundation (Copenhagen) and the Wellcome Trust (London) announce a third series of awards of these Fellowships, which they jointly instituted in 1957 The successful candidates for 1959–60 are Mr Michael Weis Bentzon, head of the Statistical Department of the State Serum Institute, Copenhagen, and Mr John Anthony Hunt, at present working in the Medical Research Council's Research Unit for Molecular Biology at the Cavendish Laboratory, Cambridge. Mr. Bentzon will work with Prof. M. S. Bartlett in the University of Manchester on the application of modern statistical theory of biological problems and Mr. Hunt will study methods of protein chemistry with Prof. M. Ottesen at the Carlsberg Laboratory, Copenhagen.

Lalor Grants and Awards for 1960

THE Lalor Foundation has announced the programme of awards for 1960 which it is offering for research in the biological sciences. These awards are to be for support of research on the fundamental biochemical and physiological mechanisms concerned with fertility and reproduction in various forms of life. The objectives are to further the knowledge and understanding of the basic phenomena involved and to extend and develop the possibilities for effective regulation and control. The awards may range up to 8,000 dollars a year, depending upon the scope and duration of the projects approved. Preference will be given to younger members of university and college staffs with an upper age limit of 45 years. The work may be carried out at the applicant's own institution or elsewhere. The Foundation will also grant postdoctorate summer or short-term research awards at the Marine Biological Laboratory at Woods Hole, Mass., or elsewhere for appropriate projects in the fields specified. For these awards, the stipends will normally not exceed 900 dollars for a single man or a woman, 1,100 dollars for a married man working at his home institution, and 1,250 dollars for a married man with principal programme at another institution. Application and inquiries should be sent to the Lalor Foundation, 4400 Lancaster Pike, Wilmington 5, Delaware, and applications must be received by January 15, 1960.

Selby Fellowship

IT is announced that Messrs. H. B. Selby Pty., Ltd., of Australia, have placed at the disposal of the Australian Academy of Science the means to establish a research fellowship, to be known as the Selby Fellowship. The intention of the gift is to recognize that, whereas there are numerous scholarships that enable Australian graduates to proceed overseas for research experience, there is now a need for measures to bring young graduates from British and other overseas universities for postdoctoral work in Australian laboratories. The Selby Fellowship is intended as a contribution to this problem. The Fellowship may be awarded for work in any branch of physical or biological science, and is tenable at any university or research institution in Australia by applicants less than thirty years of age. In general, applicants should hold the Ph.D. degree or have equivalent status and experience, but the Fellowship will not normally be given to those who have already held a senior research award. The Selby Fellowship will normally be tenable for one full year of work in Australia. This year applications will close on November 1 with the Assistant Secretary, Australian Academy of Science, Gordon Street, Canberra City, A.C.T. In future years it is intended that applications will close about June 20.

University News

Birmingham

THE following appointments have been made: to the chair of botany, Prof. J. Heslop Harrison (for a note on Prof. Heslop Harrison's work see *Nature*, 173, 150; 1954); Dr. Brenda Manly and Dr. J. Cohen, lecturers in zoology; K. A. Redish, lecturer in mathematical physics; Dr. N. A. Dyson, lecturer in physics; Dr. F. J. Wallace, lecturer in mechanical engineering; Dr. I. R. Smith, lecturer in electrical engineering; Dr. V. G. Jenson, lecturer in chemical engineering; Dr. W. B. Morgan, lecturer in geography; R. S. Hall, Research Fellow in physics; E. A. Howson, Research Fellow in electrical engineering; R. D. Hartley, Research Fellow in mining; E. Whipp, G. E. C. Hirst Fellow in the Department of Electrical Engineering; A. T. Aldred, Research Fellow in physical metallurgy; D. W. Jones, Research Fellow in physical metallurgy.

Leeds

THE following appointments to lectureships have been made: A. W. Chronowicz (civil engineering); Dr. B. F. Salvage (electrical engineering); A. L. Yettram (civil engineering).

Sheffield

THE following appointments to lectureships have been made: P. Chadwick, applied mathematics; Dr. J. N. Murrell, chemistry; C. E. Blank, medical genetics; Dr. J. Sykes, biochemistry; Dr. J. M. Hoskins, bacteriology and virology; Dr. J. Allison and Dr. A. M. Howatson, electrical engineering; K. Littlewood, fuel technology and chemical engineering; Dr. E. W. Lee, physics; L. Lehman, dental mechanics and prosthetics; T. B. Ferguson and J. D. Stringer, mechanical engineering; W. J. M. Tegart and C. W. Hawarth, metallurgy. Dr. J. F. Wallace has been appointed senior research fellow in mechanical engineering. The title of reader has been conferred on the following: Dr. A. Garnett, geography; Dr. D. R. Davies, applied mathematics; Dr. P. L. Pauson, organic chemistry.

St. Andrews

THE following appointments have been made: to readerships, Dr. D. Bijl, lecturer in natural philosophy in St. Salvator's College, and Dr. A. J. O. Cruickshank, lecturer in electrical engineering in Queen's College. Senior lectureships are as follows: Dr. J. L. Copp, lecturer in chemistry in Queen's College; Dr. F. D. Gunstone, lecturer in chemistry in St. Salvator's College; Mr. W. McNicoll, lecturer in civil and mechanical engineering in Queen's College; Dr. A. R. Mitchell, lecturer in mathematics in St. Salvator's College; and Dr. F. Walker, lecturer in geology in Queen's College.

Announcements

FOLLOWING the death of Sir Claude Gibb, it has been announced in the House of Commons that Sir Solly Zuckerman will succeed him as chairman of the committee responsible for controlling Government-financed scientific research and development. The committee was set up to consider the techniques and management of such projects.

ERRATUM. The papers referred to in the article entitled "Water-Resources and Water-Use Survey" in *Nature* of July 11, p. 96, are wrongly described in the footnote. The correct reference number is WMO No. 82 TP 32, which is published by the Secretariat of the World Meteorological Organization, Avenue de la Paix, Campagne Rigot, Geneva.

NATURE CONSERVATION AND YOUTH SERVICE IN BRITAIN

IN the past two reports of the National Parks Commission, appreciation has been expressed of the work done by volunteer groups in clearing disfigurements in the National Park areas in Pembrokeshire, Northumberland, the Lake District and the Peak District When the Council for Nature was formed in 1958, it declared its intention of forming a volunteer group of young men and women to work in nature reserves and similar areas on tasks having the purpose of preserving the flora and fauna of the countryside The Council's purpose in this project was twofold on one hand, to help the many naturalists' trusts and other bodies in managing areas of scientific interest, and on the other, to offer young people in their spare time a task in the countryside which was worth while This project was made possible by a generous grant from the Carnegie United Kingdom Trust, and in a paper read before Section X (Assembly of Corresponding Societies) of the British Association during the York meeting, Brigadier E F E Armstrong, who has been responsible for the organization of this Volunteer Conservation Corps for the Council, described the scope of the Corps and some of the experience gained and problems encountered

In contrast to the Civilian Conservation Corps of the United States, Brigadier Armstrong pointed out that the Conservation Corps is a volunteer spare-time activity, and the tasks undertaken had to be within the capacity of a group of young men and women working for the comparatively short periods they could give in holidays and vacations Moreover, it was important that the task undertaken should have a viable ultimate scientific purpose, and should not be such that it would obviously be more usefully and efficiently done by machinery Usually the tasks undertaken were those requiring manual rather than mechanical labour and suited to a group of volunteers, aged 16–23, working for periods of one, two or three weeks In practice, the limiting factor had proved to be the financial resources, and not the availability of volunteers some 400 volunteers had come forward against the 160 places that the Corps had been able to offer on 'residential' tasks, including week-end tasks and those occupying one or more weeks Generally, the volunteers were from 'sixth formers' of schools, but university undergraduates and older members of natural history societies, 'Rovers' and 'Rangers' had also been anxious to help

For the most part, volunteers were educated and already interested in natural history, and leadership could be formed on the site of the work, though the responsibility for the prior organization of the work rested with the headquarters organizer and the members of the body for whom the work is being done

Brigadier Armstrong stressed the educational side of the work The programme always included a daily evening lecture on some topic of nature conservation, followed by discussion, and efforts were made to include a visit to some other site of scientific interest in the neighbourhood and to any Nature Conservancy or Forestry Commission establishment within range The education side had been much appreciated by the volunteers, and had clearly contributed to the success of the project The Conservation Corps had already proved the existence of a very strong desire on the part of young men and women in Britain for an opportunity to assist in preserving the flora and fauna of the countryside

Reference was made to the importance of satisfactory accommodation, for this year the Corps would have its own camp for a task exceeding a fortnight, while for other tasks accommodation had been obtained in youth hostels, a Field Studies Council hostel, a hotel and in H M S *Conway* Tasks already undertaken included clearing the dogwood and other scrub which has invaded and is overrunning the grassland slopes of Juniper Top, Boxhill, clearance work in a compartment of Woodwalton Fen to open it up for fenland flora and improve it as a habitat for the large copper butterfly, clearance of scrub in Askham Bog to show regeneration of plants and removing the top layer of vegetation to provide an area of more permanent bog conditions, clearing a path in Surlingham Broad to improve access to the centre of the Broad, and shelving down banks of ponds in Newborough Warren which had been excavated by machinery and planting suitable to consolidate these edges

Brigadier Armstrong also referred to the development of week-end or single-day tasks, particularly in areas where plenty of volunteers are available and responsibility for organization could be delegated locally Such tasks, which did not involve accommodation, were likely to be less expensive to organize and it was hoped to extend the development in future

A following paper dealt with another problem also exercising concern both to the National Parks Commission and the Nature Conservancy Breaches of the Country Code, damage to farm-land and in nature reserves is frequently done by teenagers from the big cities, seeking freedom from restrictions in the country and unaware of the dangers they themselves often run or the damage they do Mrs Edie J Green, senior instructor of the Kyndwr Scwd Mountain Training Centre, Derbyshire, described a successful attempt to enlist the adventurous spirit of a group of such boys and to guide it into useful purposes A start was made with a group of eight boys drawn both from those full of enthusiasm for outdoor activities but lacking skilled guidance, and from those responsible for vandalism, usually through sheer exuberance rather than deliberate destructiveness Following essentially the principles laid down in another sphere by Elton Mayo and Mary Follett, and applied so strikingly by Lieut -Commander A H Leighton in a Japanese re-location camp, the friendship of the boys was first won, and also the co-operation and goodwill of farmers and others in the district with whom the scheme would involve contact were secured Then the boys were encouraged to frame their own rules and ultimately they produced a set of rules for the situation more impressive than the Country Code itself, breach of which was punished, by the group's own decision, by sending the offender home In practice, the rules were rarely broken, because to the boys they made sense

From this it was an easy step to the acceptance of the Country Code itself, and the boys were often heard talking to their contemporaries about what should or should not be done in the country, and Mrs Green suggested very reasonably that this is likely to have a far deeper effect than police warnings or slogans on the notice boards With this went a changed attitude to farmers Getting to know the farmers and understanding what farming meant changed the attitude of the boys into one of respect and co-operation the farmer who had provided the site for the camp found his shippen cleaned out for him and a boy who admitted to knocking down dry-stone walls for years was found attempting to rebuild one

Such changes alone would justify the continuance of such training camps from the point of view of the national parks and nature reserves alone, but the scheme also provided a definite programme for training the boys in climbing, in mountain rescue and in first-aid—at their own request Here again the boys, from being a liability or a nuisance on the hills, became competent members of a mountain rescue team, and every challenge to endurance was met with enthusiasm The experimental period described by Mrs Green also showed the value of the scheme in developing the personalities of the boys. Much clearly depends on the quality of the staff, and there is also the matter of equipment, but the new training centre which opened in September 1959 offers a first-class mountaineering course for 5*s* affiliation fee and 2*s* 6*d* at each school, and thirty boys are being taken

APPLIED MATHEMATICS AND THEORETICAL PHYSICS AT CAMBRIDGE

A DEVELOPMENT in the University of Cambridge which will be of interest generally is the formation, from October 1, 1959, of a Department of Applied Mathematics and Theoretical Physics The Department comes within the Faculty of Mathematics, and embraces the present teaching staff and research students on the applied side of the Faculty Academic staff at Cambridge traditionally divide their time between centralized university lecturing and supervision of research students (as university lecturers, readers, etc) on one hand, and informal teaching of undergraduates in their own college (as Fellows) on the other This arrangement undoubtedly has advantages for undergraduates, but it has not been without some unfortunate consequences for research in a number of subjects The various colleges provide their official Fellows with rooms, and the existence of this accommodation has retarded the development of centralized departments and buildings with adequate facilities for research Teaching and research in the experimental sciences are impossible without a properly equipped laboratory, and these subjects were the first to be provided with central University buildings Less obvious perhaps, but no less real, is the need for theoreticians to meet and work together in these days of rapid scientific developments and enlarging horizons. The formation of a Department of Applied Mathematics and Theoretical Physics at Cambridge is a recognition of this need, and is viewed as an administrative step towards the provision of central office accommodation and research facilities for the members of the Department. When that is achieved. an anomaly peculiar to the University of Cambridge will have been removed

There are two novel features of the new Department The first is that, as implied by the name, the Department includes both 'classical' and 'modern' aspects of theoretical physics and engineering science, in contrast to the usual plan in which applied mathematics and theoretical physics fall in separate university departments This unity was suggested by the existing practice of teaching both applied mathematics and theoretical physics in the Mathematical Tripos, and it was in any event felt to be appropriate The customary division between applied mathematics and theoretical physics is scientifically rather arbitrary (being prompted, perhaps, by the fact that in most universities applied mathematics is linked with pure mathematics and theoretical physics with physics) and is often unfortunate in its effects Recent work on plasma physics and magneto-gas-dynamics has shown how much the two subjects have in common and how artificial is the division between them, and the older fields of theoretical astronomy and astrophysics have long illustrated the same point The staff at Cambridge who will comprise the new Department are eighteen in number, and are engaged on work in elementary particle and field theory, nuclear physics, astrophysics, plasma dynamics, fluid mechanics and geophysics

The second novel feature is the provision that the head of the Department shall be appointed for five years at a time from among the more senior people in the Department This represents a deliberate departure from the practice in British universities of having a head with life tenure, usually the sole professor, or, where there is more than one professor, the one of greatest scientific distinction, and is more like the arrangement in many American universities The disadvantages and risks of having a permanent head are well known, the health and fate of the department are tied to the administrative ability and capacity for leadership of one person for many years, the growth of a hierarchial structure may be encouraged, the talents of a rising leader may not be given full scope, and so on There are also advantages, which may be more important in some circumstances, but there was a strong feeling at Cambridge that a more flexible scheme was desirable for the new Department A period of five years was chosen as being long enough to allow the head of the Department to formulate and carry through any schemes which may be close to his heart, and short enough to be regarded as only a temporary interruption of personal research The regulations allow re-appointment of a person for further periods of five years This experiment in administration of a university department will be interesting and may have its lessons for other departments

The first head of the Department is Dr G K Batchelor, reader in fluid mechanics He is known for his work on the theory of turbulence and other branches of fluid mechanics, for which he was elected a Fellow of the Royal Society in 1957. Dr. Batchelor was born in Melbourne in 1920 and received his first degree from the University of Melbourne in 1940. Later he went to Cambridge, where he was elected a Fellow of Trinity College in 1947 and awarded an Adams Prize in 1951. He is editor of the Cambridge Monographs on Mechanics and Applied Mathematics and of the *Journal of Fluid Mechanics*.

ENZYMES

WAGENINGEN, situated on the Rhine in eastern Holland, contains 22,000 inhabitants, and about seventy institutes for scientific research. About one-half of these institutes form part of the State Agricultural University of Wageningen, while the other half are government or private institutes.

In these pleasant surroundings, a highly successful conference on enzymes was held by the University of Wageningen during April 6–9. The organizing committee was under the chairmanship of Prof. H. J. C. Tenderloo, with Dr. H. Veldkamp as secretary.

An introductory lecture was given by E. C. Slater (Amsterdam), who emphasized the central place of enzymology in biochemistry. In his view, it is enzymology which gives biochemistry its own methodology, and its own manner of thinking. (Later in the conference, H. Booij (Leyden), speaking as an 'angry young man', provided the necessary corrective against any over-enthusiastic adoption of this proposition by pointing out that other fields of biochemistry existed.) Although there are many different enzymes, the number of different reaction types catalysed by enzymes is quite small. Life, as we know it, involves comparatively few chemical tricks, which are used over and over again, and the aim of biochemistry is to systematize our knowledge of these tricks. A significant step forward in the systematization of enzymology was the appearance in 1958 of the book "Enzymes", by M. Dixon and E. C. Webb. Studies of the mechanism of enzyme action by kinetic and isotopic methods, and by direct chemical studies in which the enzyme is used as a reactant, have confirmed the suggestion made by Michaelis and Menten in 1913 that the enzyme reacts with at least one of the substrates to give an intermediate enzyme–substrate compound. However, in many cases the intermediate enzyme–substrate compound contains only a part, sometimes a small part, of the substrate. This lecture also dealt with the uses which have been made of isolated enzymes as tools in other investigations, in particular in analytical procedures and in the determinations of the structures of compounds isolated from natural materials, such as coenzyme A.

C. de Duve (Louvain) reviewed the recent knowledge of the localization of enzymes within the cell, which has been gained by fractionation of cell homogenates, particularly by differential centrifugation. He pointed out that although the cytologist would regard the preparation of a tissue homogenate as a brutal disruption of the cell, this homogenate is able to carry out very many reactions, and it is possible to localize different reactions in different cell organellæ which can be isolated from the homogenate. He dealt at length with the theoretical basis of the various methods of separation which have been used, and discussed their advantages and disadvantages. The use of 'marker' enzymes for the main fractions of the rat-liver cell nucleus, mitochondria, microsomes and 'soluble' fraction has led de Duve to the discovery that many hydrolytic enzymes are present in granules a little smaller than mitochondria which he has named lysosomes. More recent work using the technique of density equilibrium in heavy water has suggested that at least two enzymes (uricase and catalase) are present in yet another type of granule. The enzymes within the lysosomes are inactive towards their substrates unless the granules are destroyed mechanically or by suspension in hypotonic solution. The lysosomes also discharge their enzymes into the cell when the latter becomes anaerobic, thus promoting autolysis of the cell.

P. Desnuelle (Marseilles) spoke about the chemical structure of proteins and mechanism of action of proteolytic enzymes. He pointed out that although the chemical structures of insulin and of the polypeptides melanocyte-stimulating hormone and adrenocorticotrophic hormone are now established, the reason for the activity of the whole molecule is not yet known. He discussed what is known about the primary, the secondary and the tertiary structures of proteins, emphasizing that although other structures are theoretically possible, the open-chain is the only type which has been clearly demonstrated. Desnuelle described recent work on the activation of the precursors (the -ogens) of the pancreatic proteolytic enzymes, which has shown the importance of limited proteolysis in this process. Actually, the activation of chymotrypsin and trypsinogen is brought about by the splitting of a single bond. But this splitting is likely to be the first and necessary step for deep changes in the tertiary structure of the precursor, bringing two or three residues at the right position in space for building an 'active centre'.

E. C. Webb (Cambridge) surveyed the properties of the various coenzymes, prosthetic groups and activators of enzymes. He pointed out that metals sometimes act as carriers, sometimes promote the combination of the enzyme with the substrate. The effects of anion activators were discussed in relation to his own recent studies of the activation of arylsulphatase by chloride.

A discussion between Dr. Webb and Prof. Slater on whether a valid distinction could be drawn between a coenzyme and a prosthetic group led to the agreed definition that a compound acts as a coenzyme if during the course of its catalysis of the reaction it reacts first with one enzyme and then with another, and as a prosthetic group if it remains bound to the one enzyme during the course of the reaction. The same substance can in different reactions act as a substrate, a coenzyme or a prosthetic group.

Sir Rudolph Peters (Cambridge) discussed enzyme inhibitors, illustrating the different types by reference to carbon–fluorine compounds (for example, fluorocitrate), arsenicals and organo-phosphorus compounds. The recent studies at Babraham on the mechanism of the inhibition of aconitase by fluorocitrate were presented In the discussion of arsenical inhibitors, emphasis was placed on the different actions of monosubstituted (for example, lewisite, mapharside) arsenicals, which inhibit pyruvate oxidation, and disubstituted (for example, diphenylchlorarsine) compounds which inhibit isocitric dehydrogenase, as well as on the practical application of 2,3-dimercaptopropanol in reversing the inhibition by arsenicals

The organo-phosphorus inhibitors were discussed in relation to their action on cholinesterase, and to the reversing effect of pyridine-2-aldoxime methiodide As an example of antimetabolites, Sir Rudolph discussed the antagonism of the effect of serotonin by 1-benzyl-2,5-dimethyl-serotonin

F Dickens (London) discussed the regulation of enzymic reactions within the cell with special reference to carbohydrate metabolism Regulation can be provided by structural barriers within the cell, but also by enzymic mechanisms which do not require structural separation of reactants Examples of the latter type are given by (1) control of rate of mitochondrial respiration by the concentrations of inorganic phosphate and adenosine diphosphate , (2) 'feedback' by inhibition of the enzyme by the product of the reaction, for example, inhibition of hexokinase by glucose-6-phosphate , (3) the existence of different mechanisms for breakdown and synthesis, for example, the equilibrium of the uridine diphosphoglucose pathway of glycogen synthesis is much more favourable to synthesis than is the reversal of the phosphorylytic breakdown Dickens directed attention to situations where the pentose phosphate pathway is particularly active in relation to glycolysis, for example, in the lactating mammary gland, where its function is probably to provide reduced triphosphopyridine nucleotide for fat synthesis, and in the lens where its function is possibly to provide the same compound to keep glutathione reduced

H Chantrenne (Brussels) concluded the conference by a discussion of the present status of the investigation of the mechanism of protein synthesis in general, and of enzyme synthesis in particular He pointed out that the earlier sharp distinction between adaptive and constitutive enzymes has been abandoned The recent work of Ingram on abnormal hæmoglobins has shown that even the fine details of the protein structure are controlled by the gene A mutation of a single gene causes a change of one amino-acid in the polypeptide chain It is conceivable that the deoxyribonucleic acid of the gene contains the information which determines the sequence of amino-acids in the protein chain This information must be transferred to the ribonucleic acid in the cytoplasm, where the protein is synthesized The function of the inducer, the presence of which is necessary for formation of an enzyme, is not known However, it has been shown that it acts in catalytic amounts, not autocatalytically This suggests that it acts on an enzyme-synthesizing mechanism which is already present, perhaps in an inhibited form In the discussion of this paper, Desnuelle pointed out that enzyme activity requires a specific configuration (tertiary structure) of the polypeptide chain The native form of an enzyme is a unique, unstable structure among many more stable structures It is, therefore, likely that not only the arrangement of the residues along the chains but also the specific folding of these chains are gene-controlled This must be taken into account in any consideration of enzyme synthesis

An unusual feature of this conference which had much to recommend it was that the programme called for only two speakers each day, one in the morning and one in the afternoon This enabled the speakers to give a long introduction (about 45 min) for the benefit of non-specialists, before a coffee or tea break, after which the speaker continued for a further 30–45 min A discussion then followed E C SLATER

ENERGY TRANSFER WITH SPECIAL REFERENCE TO BIOLOGICAL SYSTEMS

THE mechanisms by which energy may be transferred from one atom or molecule to another have become a prominent theme of chemical kinetics, photochemistry and radiation physics—as well as of many biological processes The same fundamental processes and many of the outstanding problems are common to each of these sciences, and those of biological systems, in particular, depend for their solution on development in other fields The efficiency and generality of energy transfer between molecules has been fully appreciated only quite recently, and the discussion on this subject, which was held by the Faraday Society at the University of Nottingham during April 14–16, was one of those timely meetings for which the Society is noted It was attended by two hundred physicists, chemists and biologists, about one-quarter of whom were from overseas

The discussion was divided into two parts, the first concerned with energy transfer processes in general and the second with their occurrence in biological systems After the president, Dr E W R Steacie, had welcomed the overseas visitors, the Spiers Memorial Lecture on "Transfer Mechanisms of Electronic Excitation" was delivered by Prof Th Forster, of the Technischen Hochschule, Stuttgart This provided an excellent introduction to the first part of the discussion, which was concerned almost entirely with this topic The transfer of electronic excitation energy from one molecule to another can be a very efficient process which may occur, not only at every encounter, but even over distances of 50 A or more Apart from the 'trivial' process involving emission and re-absorption of light, this transfer can proceed by a radiationless mechanism known as resonance transfer, the interaction between the molecules being one of dipole–dipole coupling and not overlap of electron orbitals which is significant only at much smaller distances The process is often also referred to as the Forster mechanism, and Prof Forster gave a clear account of the quantitative theory which he, principally, has developed He discussed the application of the theory to forbidden transitions, transfer within one molecule and between like molecules, and pointed out that conditions for excitation energy transfer are very favourable in biological systems since Nature often prefers a high local concentration of absorbing matter

The first four papers of the discussion were all concerned with electronically excited organic molecules Prof G Porter and Dr M R Wright (University of Sheffield) discussed processes of deactivation involving change of multiplicity In particular, they presented rate constants for the decay of triplet states of aromatic molecules in solvents of varying viscosity and in the presence of paramagnetic molecules and ions and gave an interpretation of the latter process in terms of overall spin conservation rather than magnetic perturbation of spin-orbital coupling Dr A Weller (Technischen Hochschule, Stuttgart) described his work on the reactions of excited singlet state molecules, with particular reference to acid-base equilibria and proton transfer in the excited state Dr B Stevens (University of Sheffield), in the only paper dealing with the vapour phase, described experiments which showed that transfer of energy from electronically excited benzene to anthracene occurred over an average distance of 7 6 A Dr E J Bowen (University of Oxford) described fluorescence studies of the excited singlet states of anthracene derivatives, with particular reference to the influence of temperature and solvent viscosity The data indicate that two processes of radiationless conversion—probably to triplet and ground state—are operative

There was much discussion following these papers, most of which was about radiationless transitions and particularly the effect of viscosity upon them Prof Porter had interpreted this effect in terms of different configurations of the two states, and Dr Bowen's explanation involved the attainment of a certain amplitude of vibration Prof H C Longuet-Higgins (University of Cambridge) thought that it was the removal of energy by the solvent which was important and that the greater efficiency of solvents of low viscosity was a result of their having the lower-frequency components necessary for this transfer Dr D H Whiffen (University of Birmingham) suggested that it is molecular rotation which is important and that a time-dependent mixing of singlet and triplet states is introduced by interaction between rotation and spin-orbit coupling Prof J D Bernal (Birkbeck College, London) pointed out the importance of structure and the inadequacy of viscosity as a measure of microscopic properties—a point which was emphasized by other speakers No general agreement was reached on these alternative theories in spite of the very valuable discussion

The second scientific session began on the morning of April 15, with four papers on electronic energy transfer in solution Dr F H Brown, Dr M Furst and Prof H P Kallman (New York University) gave an account of their extensive work on energy transfer in rigid and liquid organic scintillator systems induced both by light and by ionizing radiations In these solutions as much as 10 per cent of the energy absorbed by the bulk material is emitted by the solute, and three mechanisms, in addition to the radiative one, are involved under various conditions These are (*a*) material diffusion transfer (in liquids only) , (*b*) migration transfer , (*c*) single step transfer Dr J B Birks and K N Kuchela (University of Manchester) described similar studies in polystyrene solutions as a function of wave-length At concentrations greater than 10^{-4} molar the transfer was found to be non-radiative Prof M Burton and H Dreeskamp (Notre Dame University) described the measurement of luminescence decay times in scintillator systems by a method utilizing X-ray pulses of about 10 mμsec duration and concluded that the measured decay times were characteristic of excitation transfer processes Prof M Dole (Northwestern University, U S A) and Dr T F Williams (Atomic Energy Research Establishment, Harwell) described further studies of the disappearance of unsaturated linkages on γ irradiation of polyethylene, the high *G* value of which shows that energy transfer processes must be operative

In the discussion on these papers, Prof Kallman pointed out that the life-time of anthracene vapour molecules is shorter by an order of magnitude than that found in condensed phases, which Bowen suggested might be due to the fact that emission involves higher vibrational states of the excited gaseous molecule Dr Stevens said that the longer measured life-time in condensed media was probably due to re-absorption effects, a view shared by Birks, who emphasized that the 'molecular' life-time in condensed phases is as short as that found in the gas Prof Burton warned against over-confidence in values obtained by the phase-shift technique, since analysis of the data assumed an exponential decay which may not always be observed

Dr A Szent-Gyorgyi introduced the papers on "Energy Migration in Biological Systems" with a summary of the various ideas that have been introduced in the past fifteen years semiconductivity, resonance energy transfer and electron transport Dr Szent-Gyorgyi dealt more specifically with the electron flow in the respiratory chain and introduced a suggestion of his own, namely, that the partial charge transfer complexes that have been intensively studied during the past few years are the first steps in the one-electron oxidation processes that Michaelis first postulated

These various aspects of energy transfer were dealt with in detail in the papers that followed M H Cardew and Prof D D Eley (University of Nottingham) reported measurements on the semiconductivity of amino-acids, hæmoglobin and globin Their findings of small conductivity with activation energies of the order of 3 eV are in agreement with the values expected for a hydrogen-bonded CO HN system R Mason (University College, London) described some possible instances of charge transfer in proteins, which have not yet found empirical foundation Dr G Weber and F J W Teale (University of Sheffield) reported on energy transfer in the hæm proteins which results in the quenching of the tryptophan fluorescence of the native proteins and of the fluorescence of a conjugated group in hæm–protein conjugates The results, which are in general agreement with Forster's theory, permit some conclusions about the distribution of the hæms on the surface of hæmoglobin A paper by Prof Q H Gibson (University of Sheffield) described how hæmoglobin formed from CO-hæmoglobin by a light flash had a much greater reactivity towards carbon monoxide than the ordinary hæmoglobin into which it reverted spontaneously with a rate of 200 $\sec^{-1}$

Four papers dealt with energy migration in photosynthesis The background to the problems was presented by Prof B Rabinowitch and Dr S S Brody (University of Illinois), who pointed out the unique structural features of the chloroplast as revealed by the light and electron microscopes and the difficulty, if not the impossibility, of reproducing these features in our simple model systems When the probable ways of energy migration in the chloroplast are considered the resonance transfer among some 200 chlorophyll molecules forming a photosynthetic unit appears the most likely Prof R Lumry (University of Minnesota) presented work by himself, J D Spikes and B Mayne in which simultaneous measurements of Hill reaction velocity and fluorescence yield were carried out The parallelism of the two phenomena strongly favours the idea of a trapping centre to which the energy is transferred by resonance after its absorption by chlorophyll and where it is utilized in competition with the fluorescence and other radiationless deactivation processes A paper by Dr L N M Duysens and J Amesz (University of Leyden) dealt with the quantum requirements of diphosphopyridine nucleotide in photosynthesis From this paper, as well as the previous work of Dr Duysens on the oxidation of cytochromes, and from recent data that Prof Britton Chance and T Yonatani (University of Pennsylvania) presented in the course of the discussion, in which fast simultaneous recordings of cytochrome oxidation (by absorption) and diphosphopyridine nucleotide reduction (by fluorescence) were obtained, it appears now certain that the simultaneous oxidation of cytochromes and reduction of diphosphopyridine nucleotide are among the earliest events in photosynthesis Prof R Livingston (University of Minnesota) and Prof A Terenin, E Putzeike and I Akimov (University of Leningrad) dealt with properties of isolated chlorophyll, namely, the quenching of the triplet state and the photoconductivity, respectively Dr W A Hagins (National Institutes of Health, Bethesda) and W H Jennings (Duke University, U S A) presented experiments which showed the localization as opposed to migration of the excitation in the retinal rods, while M J Cowan, J M F Drake and Dr R J P Williams (University of Oxford) examined chelates of iron as models for the understanding of the variations in spectrum and redox potential of the cytochromes

A paper by Prof Britton Chance and E L Spencer (University of Pennsylvania), which described the rapid establishment of redox equilibria in the cytochromes of cells and cell particles at the temperature of liquid nitrogen, was interpreted by the authors as suggesting a solid-state mechanism of electron flow among the cytochromes

Prof D E Green (University of Wisconsin) concluded from the analysis of linked respiratory chain reactions that the electron transport is essentially a solid-state process occurring in a lipid phase , but the discussion that followed this paper showed that the evidence was not regarded as in any way conclusive

In a discussion of energy in the biological systems, adenosine triphosphate could not be omitted Although no paper dealt specifically with the properties of adenosine triphosphate, these were the subject of a lively discussion Briefly, some speakers thought that adenosine triphosphate has had greatness thrown upon it by the accident of evolution, a distinction which may just as easily have fallen on its humble cousin pyrophosphate Others believed that the rest of the molecule will be found to be indispensable in energy transfer Prof J A V Butler (University of London) summarized the evidence for the first view Dr J H Turnbull (University of Birmingham) put forward the case for the latter

The past twenty years have seen great improvements in the methods that reveal the purely structural features of biological systems Because of their success we have come to look for explanations of biological events in terms of structural factors alone The energetic aspect is equally important and indeed complementary to the structural, and this meeting rendered a good service to the biological sciences by bringing attention to this often neglected point

G Porter
G Weber

HEATING BY ELECTRON BOMBARDMENT

Electron bombardment heating is produced by accelerating electrons from a thermionic cathode on to a specimen, by means of a d c voltage Simple focusing of the electron paths enables the heating to be highly localized and melting is achieved with very small power requirements These facts, together with an ease of power control and the necessity for vacuum operation, explain the preference for heating by electron bombardment in some applications Although used for very many years it is only recently that this method of heating has become more widely known through its application to the melting of refractory metals for the purpose of floating-zone melting[1], welding[2,3] and evaporation[4] The growing interest in this technique was shown by the attendance of one hundred and sixty visitors, from British and overseas laboratories, at a symposium on "Electron Bombardment Floating-zone Melting and Allied Electron Bombardment Techniques", held at the Services Electronics Research Laboratory, Baldock, Herts, on March 10

Several papers on electron bombardment floating-zone melting were given In this method, a rod of the material being purified is held at both ends in a vertical position and a molten zone is induced in it by bombarding it with electrons from a circular cathode The molten zone is held stable by surface tension and this imposes an upper limit[5] on the maximum zone length, and hence diameter, of the specimen to be zoned Relative longitudinal movement between the cathode and rod moves the zone along the rod and zone-refining takes place The purified rod often becomes a single crystal Metals sometimes out-gas violently when melting for the first time in a vacuum, and a bombardment-current controller[6,7] is necessary to stabilize the current, which tends to fluctuate under these conditions Whereas vacuum operation is advantageous when zoning reactive metals, it has the accompanying disadvantage that considerable material may be lost by evaporation This has led most experimenters to use zone travel speeds which are too fast for segregation of impurities, and purification is obtained mainly by evaporation of the lower melting point impurities from the molten zone and by out-gassing *in vacuo*. A criticism of the method is that contamination of the specimen by the cathode can occur and is occasionally detected. This can sometimes be overcome by using a cathode of the same material as the specimen, for example, tantalum, rhenium, or by designing a cathode system which 'hides' the cathode from the molten zone. No speaker reported any experiments on this aspect.

A. Calverley (Services Electronics Research Laboratory, Baldock, Herts) described an improved electron bombardment apparatus[8] which overcame the limitations of poor operating vacuum, visibility and speed range of his earlier apparatus[6]. The main features of the new apparatus are similar to those of the Services Electronics Research Laboratory silicon crystal puller[9], and zone-refining of refractory metals and semiconductors can be done in a vacuum of $\sim 10^{-6}$ mm. mercury and sometimes better. Of great practical value is the ability to move vertically up or down that part of a specimen below the molten zone during the zone-refining operation. This enables variations in the diameter of the specimen, which occur during preliminary out-gassing, to be corrected and it can also be used for determining the length of the molten zone, for with some metals it is difficult to see the boundary between the solid rod and liquid zone. With low melting-point metals such as aluminium, gold and copper, stable zones are difficult to maintain, but no difficulty is experienced with the more refractory metals. Work with the earlier apparatus was of an exploratory nature and single crystals of tungsten, rhenium, tantalum, molybdenum, rhodium, niobium, iridium, ruthenium, platinum and nickel were made ranging in size from 2–5 mm. diameter and up to 18 cm. long. The properties of these crystals are often found to be much closer to those of a perfect metal than was the case with the best specimens previously available. For example, zone-melted molybdenum was found[10] to have the same tensile ductility at − 196° C. as arc-melted molybdenum at − 30° C., and the superconducting properties of tantalum prepared in this way were found to be quite close to those of an ideal superconductor[11]. At the moment, work with this apparatus is concentrated on producing pure crystals of tantalum, vanadium and niobium for superconductivity studies, these metals being obtainable with Vickers hardness numbers 68, 79, and 38 respectively. The smallest specimen so far zoned is a 0·060 in. diameter tantalum rod. With alloys, the ability to zone-melt them depends on the vapour pressure of the constituents at the melting point of the alloy. Thus whereas tantalum–niobium alloys may be zoned, tantalum–vanadium alloys of high tantalum content cannot be melted without almost complete evaporation of the vanadium. Although possessing a high resistivity at room temperature, boron can be zone-melted providing a short electrical conduction path is maintained for the initial heating of the specimen, that is to say, if the bombarded region is within 2–3 cm. of the specimen holder. Once the temperature of the boron rises, its resistivity drops and normal zoning can take place. Boron is prone to thermal shock fracture so that heating, cooling and traversing of the specimen has to be done slowly.

F. O. Jones (Associated Electrical Industries, Ltd., Research Laboratories, Aldermaston) has prepared molybdenum–rhenium (50/50) and uranium–zirconium (70/30) alloys and concludes that, providing the vapour pressure of a constituent of an alloy is less than 10^{-3} mm. mercury, the alloy can be zone-melted without undue loss. A description of preliminary work on molybdenum–rhenium alloys was given by A. Lawley (University of Pennsylvania). His apparatus differs from that of the other speakers at the symposium in that it is a typical bell-jar system with all components mounted on a common base-plate.

Molybdenum crystals up to ½ in. in diameter have been grown by J. A. Belk (Armament Research and Development Establishment, Fort Halstead), moving the zone up a rod of swaged arc-cast material. Their axes were in the section of the unit stereographic triangle bounded by (001), (101) and (112). Tensile tests showed an absence of a sharp yield-point at the pure end, and there was a reduction of carbon from 0·008 to 0·002 weight per cent. A more sensitive method of analysis is required before any conclusions of the movement of carbon by zone-refining could be drawn. The zone-melted material showed very much lower impact transition temperatures than arc-cast molybdenum, both in single crystal and polycrystalline form. For a carbon content of 0·002 weight per cent the values were − 140° C. and − 50° C. respectively. Alloys of molybdenum with tungsten had been produced either by sintering and zone-melting a powder compact, or by melting a molybdenum rod with a close wound helix of tungsten wire. Some preliminary experiments on electron beam melting[12] were reported. In this technique, molten drops from the lower end of a bombarded rod are allowed to fall into a cooled crucible and ingots of large diameter of vacuum-melted material are produced in this manner. The experiments indicated that the power requirements were at least double those required for floating-zone melting. Out-gassing of the rod assumed much greater importance due to the increased rate of melting, and an emission-current limiter was required in addition to the normal type of emission-current controller.

F. O. Jones described his work on carbides and has found that titanium carbide (TiC) and tungsten carbide (WC) decompose at temperatures lower than their melting points. Tungsten carbide (W_2C) melted but decomposed with loss of carbon, and tantalum carbide (TaC) partially melted but also decomposed with loss of carbon. A. Calverley has found that vanadium diboride likewise decomposed with loss of vanadium.

Work on cobalt has been carried out by H. Uwents (Rijks Universiteit, Gent). After 10 passes at a zone speed of 30 cm./hr. on a 0·5 cm. diameter cobalt rod, he obtained a specimen which, after etching, revealed a small number of relatively large grains. X-ray diffraction photographs on either side of what appeared to be grain boundaries yielded the same diffraction patterns, from which he concluded they were in fact sub-boundaries. It seems possible to grow single crystals of materials which have a transformation point, by zoning at temperatures slightly higher than the transformation point.

The contribution of D. W. Rhys (Mond Nickel Co., London) was concerned with the electron bombardment floating-zone melting of platinum, ruthenium, rhodium and iridium, interest in this technique for the last three metals resulting from the lack of ductility normally encountered at room temperature. Analyses of a platinum bar zone-melted twelve times at 60 cm./hr. showed that major purification occurred by preferential evaporation of impurities, but there was nevertheless evidence of zone segregation, though at this high rate of traverse the process was inefficient. Contamination of platinum by tungsten from the filament can occur, and in some instances the product may be inferior to the starting material. Ruthenium single crystals prepared by the method can be bent readily but have not yet been cold worked successfully, and analyses of zone-melted bars have shown that purification occurs chiefly by preferential evaporation. A rhodium single crystal bar prepared by zone-melting could be cold swaged to a 90 per cent reduction in area but on subsequent annealing became polycrystalline and possessed negligible cold ductility[13]. Iridium single crystals prepared by the method are also more ductile than the polycrystalline material and, in this metal, zone segregation of nickel was observed, though the majority of impurities were reduced by preferential evaporation.

W. P. Allred (Battelle Memorial Institute, Ohio) also reported on the zone-refining of the platinum-group metals. He finds that zone speeds of 7.5 cm./hr. give little segregation of impurities whereas a speed of 1.25 cm./hr. gave very effective segregation, reducing most of the impurities below the spectrographic limit. Vacuum fusion analyses show the oxygen, hydrogen and nitrogen content to be as low as from 7 to less than 0.2 p.p.m.

One cannot bombard an insulator continuously with electrons because the electrons are unable to escape from the bombarded region, and the potential difference between cathode and target is reduced to zero. To overcome this difficulty, the insulator is bombarded at a voltage such that the ratio of secondary to primary electrons is greater than unity, and a secondary electrode is arranged to collect the secondary electrons. A communication was sent to the symposium by T. Bridges and R. Strnad (Bell Telephones Laboratories) describing their work on zone melting of single-crystal sapphire rod 0.1 in. in diameter. They find that the bombarding voltage is restricted by the above condition, the vapour pressure is high and power requirements for a completely molten zone are much higher than those for surface melting only.

Talks on other applications of heating by electron bombardment followed those on zone-melting. G. W. Warren (General Electric Co., Research Laboratories, Wembley) described the out-gassing of molybdenum in the solid state at a pressure less than 10^{-7} mm. mercury. The molybdenum specimen and bombarding system are mounted in a glass envelope which is baked and sealed-off from the pumping system after firing a barium getter. The air-cooled barium film absorbs any gas evolved from the molybdenum, which after heating for 8 hr. at 2,100° C. has an oxygen content of 1 p.p.m.

With floating-zone melting, a rod which is held at the ends only can only support one molten zone. To obtain the advantages of multiple-zone melting, P. le Couteur (General Electric Co., Research Laboratories, Wembley) used horizontal zone-melting to purify germanium. Focused electron bombardment enables narrow zones, another pre-requisite of efficient zone-refining, to be obtained. The use of a vacuum instead of a gas ambient has further lowered the ultimate impurity distribution.

Analysis of zone-refined specimens has placed fresh problems on the analyst. C. A. Parker (Admiralty Materials Laboratory, Holten Heath) reviewed the present methods available for analysing high-purity materials. One of the main problems is to obtain reagents which are as pure as the material being analysed. To avoid the use of reagents, one can either use emission spectroscopy or solid-source mass spectrometry and these have in favourable cases a limit of detection of 1 in 10^8. To investigate impurity-levels lower than this it is necessary to label the impurity atom within the sample before carrying out the analysis. The most commonly used method is to expose the sample to a flux of thermal neutrons by inserting it into an atomic reactor. The atoms become radioactive and impurities can be separated out by chemical treatment. Any contamination by corresponding impurities in the reagents has no effect on the subsequent Geiger counter reading. The sensitivity for this type of analysis may be as low as 5×10^{-12} gm., but unfortunately for some elements, either the neutron absorption is too low or the isotope produced has too short a life-time. However, proton activation is being developed as an alternative to neutron activation for some of the light elements. The principle here is the same, but instead of labelling the impurity atoms by irradiation with neutrons, they are exposed to a beam of high-energy protons from a cyclotron. Using this method quantities of boron in silicon can be determined down to 1 part in 10^9. Activation analysis by protons and other particles such as deuterons is still in its infancy, but it seems likely that methods for the determination of other light elements, including oxygen and nitrogen, will be developed in due course.

The ease with which a molten drop of metal can be produced on the end of a vertically suspended rod using electron bombardment heating had made possible the determination of the surface tension of refractory metals at their melting point. A. Calverley described his drop weight surface tension measurement of liquid tungsten[14]. His value of 2,300 dynes/cm. is approximately 380 dynes/cm. less than Taylor's estimated value[15]. A solitary determination for tantalum gave 2,020 dynes/cm., which is 310 dynes/cm. less than Taylor's value. However, J. C. Kelly (Atomic Energy Research Establishment, Harwell) has used the sessile drop method for one determination only and obtained a value for tantalum which is in agreement with Taylor's value.

J. C. Kelly described the evaporation of thin films of tantalum and zirconium[4] from a pendant drop on the lower end of a vertical rod. A simple arrangement of focusing plates enables contamination by the cathode of the drop or the target to be avoided. He has observed that, above a certain temperature, oscillations of the pendant drop occur. The rate of evaporation from pendant drops bombarded with electrons is the subject of a recent paper by Heavens[16]. Its application to 'Evaporion' pumps was discussed by L. Holland (Edwards High Vacuum, Ltd., Crawley, Sussex).

A silicon crystal pulling furnace using heating by electron bombardment was described by D. B. Gasson (Associated Electrical Industries, Ltd., Aldermaston). A central pool of molten silicon in a randomly shaped silicon charge resting on a water-cooled hearth is maintained by beams of electrons from four guns situated approximately 12 in. above the silicon to reduce mutual contamination. Each beam can be focused individually and its power varied. This obviates the need for seed rotation because the thermal condition of the melt can be varied at will. The oxygen content of crystals prepared in this furnace is similar to that found in silicon rods prepared by floating-zone melting in a vacuum or dry hydrogen.

The construction of nuclear fuel elements necessitates the welding of a variety of reactive metals and their alloys, such as zirconium, titanium, molybdenum and beryllium. Welding by electron bombardment heating[2,3] has been found to give a better-quality weld for most metals than welding in an inert gas. P. Thomé (Centre D'Etudes Nucléaires de Saclay, France) described various electron guns in which the electron beam is focused to a target spot ranging in diameter from 0.01 mm.^{2} to 0.3 mm.^{2} for 20 m.amp. and 1 amp. bombarding currents respectively at 20 kV. The beam of electrons passes through a hole in an earthed screen situated close to the components being welded, which are also at earth potential. This reduces the risk of glow discharge and arcing when fusion occurs. A further advantage is that there is no variation in the focus size with different shapes of pieces being welded. With the use of pulse heating, it is possible to apply a very high power to a small area and, if the speed of the work-piece is correctly related to the frequency of beam chopping, the weld consists of a series of overlapping spots. This permits a greater weld penetration and avoids the collapse of the sides of the weld due to metal flow which may happen in continuous welding, and also minimizes the area of recrystallization.

The general impression left by the conference was that in spite of some fundamental disadvantages, heating by electron bombardment will continue to play an important part in the science and technology of the more refractory metals and insulators, and will undoubtedly find other applications in high-temperature researches.

A. CALVERLEY

[1] Davis, M., Calverley, A., and Lever, R. F., *J. Appl. Phys.*, **27**, 195 (1956).
[2] Stohr, J. A., *le Vide*, **13** (75), 163 (1958).
[3] Wyman, W. L., *Welding J. Res. Supp.* (Feb. 1958).
[4] Kelly, J. C., *J. Sci. Instrum.*, **36**, 89 (1959).
[5] Heywang, W., *Z. Naturforsch.*, **11a**, 238 (1956).
[6] Calverley, A., Davis, M., and Lever, R. F., *J. Sci. Instrum.*, **34**, 142 (1957).
[7] Allenden, D., *J. Sci. Instrum.*, **36**, 66 (1959).
[8] Birbeck, F. E., and Calverley, A., *J. Sci. Instrum.* (in the press).
[9] Marshall, K. H. J. C., and Wickham, R., *J. Sci. Instrum.*, **35**, 121 (1958).
[10] Spacil, H. S., and Wulff, J., "Molybdenum", 13 (Amer. Soc. Metals, 1958).
[11] Mendelssohn, K., *Canad. J. Phys.*, **34**, 1319 (1956).
[12] Smith, H. R., "Vacuum Metallurgy", chap. 14 (Chapman and Hall, London, 1958).
[13] Calverley, A., and Rhys, D. W., *Nature*, **183**, 599 (1959).
[14] Calverley, A., *Proc. Phys. Soc.*, B, **70**, 1040 (1957).
[15] Taylor, J. W., *Metallurgia*, Manchr., **50**, 161 (1954).
[16] Heavens, O. S., *J. Sci. Instrum.*, **36**, 95 (1959).

TRANSISTOR CONVENTION AND EXHIBITION

AN International Convention on Transistors and Associated Semiconductor Devices was held at Earls Court, London, during May 21–27. The Convention was organized by the Electronics and Communications Section of the Institution of Electrical Engineers, which also promoted the International Transistor Exhibition held at Earls Court during the same period. The opening lectures were given by Prof. J. Bardeen, Dr. W. H. Brattain and Dr. W. B. Shockley. Some thirty further lectures were distributed among the eleven general and eleven specialist sessions that followed (mostly two at a time in parallel), brief summaries were presented of some eighty original papers, and some thirty-seven further original papers, of which either the full text or a brief digest had been previously circulated to those attending the Convention, were taken as read. The discussions at the sessions were rarely lively, perhaps because of the size and formality of the meetings and the acoustical defects of the halls (it was surprising not to find transistorized roving microphones provided to overcome this difficulty).

In his lecture Shockley considered the factors limiting the capabilities of the 'transistor-diode'—a silicon transistor operated without external base connexion up to voltages at which avalanche multiplication at the collector junction compensates for the initially low injection efficiency of the emitter—as a fast switch for heavy currents. The tendency (due to the transverse ohmic voltage drop in the base region) for part of the emitter junction to draw to itself current from the rest could be overcome by switching on quickly enough after ensuring (by a suitable controlling wave-form) that the whole of the emitter is first just-sufficiently turned off. As an example an oscillogram was shown of a current pulse rising to 50 amp. in 20 mμsec. across a load of about 0.5 ohm. In a separate paper Shockley showed that the minimization of the total capacitance of the emitter junction (also necessary in the device just considered) requires an optimum finite depletion layer thickness, on account of carrier storage in the layer.

Pritchard's lecture brought out the unsatisfactoriness of present commonly used equivalent circuits for transistors, particularly as regards the representation of the base resistance. Linvill generalized the Thevenin and Norton representations of a 2-terminal network to cover 2-ports, including the effects of internal 'contamination' generators representing, for example, noise or the dependence on temperature of d.c. parameters, and showed how the choice of an optimum source impedance could be solved generally for each of the last two situations. J. J. Sparkes showed that for some proportion of transistors the components $C_{b'e}$ and $G_{b'e}$ of the hybrid-pi equivalent circuit depart from their expected dependence on frequency, and suggested that the departures could be accounted for in terms of minority-carrier storage either in the emitter region or laterally in the base region. The effect could be correlated with anomalies in the switching characteristics.

The concept of charge-control (in contrast to current-control as generally considered typical of a transistor and voltage-control of a vacuum tube) was applied in detail by Beaufoy and by Kruithof to the quantitative description of the switching characteristics of transistors, and a generalized justification of the concept was presented in the lecture by Prof. Middlebrook.

Several papers set out to consider costs as related to some of the combinations of technologies now possible in the manufacture of transistors in large quantities. Although full agreement was lacking (not surprisingly, in view of the different markets and different degrees of reliability sought), a consensus of opinion seemed to favour one or other form of 'mesa' geometry, using diffusion alone or together with alloying, as the structure of the future. By the use of 'photo-lithographic' or other masking methods, large numbers of junctions could be completed simultaneously on each wafer of germanium or silicon, leaving a minimum of handling for the mounting and encapsulation of the individual transistors.

Atalla reported experiments on the electrical stability of silicon surfaces on which a thick (300 A. or more) oxide layer had been grown by exposure to water vapour or oxygen at about 1,000° C. Such surfaces showed exceptional freedom from effects usually ascribed to changes in the density or nature of 'slow' electronic trapping states on the outer surface of the oxide; a reversible creep effect observed for a humid ambient in the leakage current of a p–n junction having such a surface treatment was ascribed to the inversion layer induced in the underlying silicon on one side of the junction by the mobile ions electrolytically separated in the adsorbed water film as a result of the bias voltage applied across the junction. The oxide layer itself could withstand some 0.1 V. per angstrom of thickness and should preferably be made thick enough to support the full breakdown voltage of the bulk p–n junction.

The reliability of complete devices was considered explicitly in two papers, one of which showed that the activation energy for the ageing mechanism for a particular type of p–n–p alloyed germanium unit was about 1.2 eV., the end of useful life being brought about by the onset of rapid increase in leakage current and noise in a way characteristic of attack by water on the germanium surface.

A number of papers were devoted to the electrical parameters of semiconductor devices, and to their measurement. The frequency limitation (at about 1,000 Mc./s.) set by the base width of transistors could be avoided by using single junction devices such as the variable-capacitance diode, and the diode proposed by Esaki in which the depletion layer is so thin as to allow tunnel effect to dominate the behaviour at low forward biases. It was necessary in high-frequency measurements to bring the point of measurement as close as possible to the envelope of the device. Measurements in the switching field were dominated by the charge-control approach, which uses rectangular wave-forms and *CR* networks.

Sixty-four papers were devoted to applications; computers and switching applications were much the most prominent. Here the low power consumption and promised high reliability of transistors were seen to be of paramount importance, particularly as the earlier limitations on speed of operation were being largely overcome by developments in high-speed switching transistors. Chaplin illustrated the use of selected high-frequency alloy transistors (having a cut-off frequency of current gain of only about 10 Mc./s.) in the avalanche mode to generate pulses with times of rise of the millimicrosecond order.

Second in prominence to computers was the field of communications; here once again the transistor could reduce the size and power consumption of both mobile and fixed equipment and sometimes obviate the need for buildings. A paper by Grosser on space-division electronic telephone exchanges illustrated the important part that the *pnpn* structure can play as a substitute for a cross-point switch. Cave, Neu and Sim have used some specially made point-contact germanium diodes as variable reactance modulators to control up to several hundred milliwatts of power at millimetre wave-lengths, with switching times as low as 3 mμsec.

Power diodes, silicon four-layer controlled rectifiers, and power transistors were all being applied to power supply and control. Besides emphasizing the small size and high efficiency of these devices, papers directed attention to the protection problems arising from the rapidity with which damage can occur.

In instrumentation, the diverse properties of semiconductors were being applied to a very wide range of applications. There were papers on the design of Hall effect multipliers, and also on single-crystal infra-red detectors using intermetallic compounds. Klein and Straub suggested that fast-neutron dosimetry could be carried out by electrically assessing the damage caused in germanium and silicon, and proposed an assembly of high-resistivity p-type germanium and lithium-6 for thermal-neutron dosimetry. McKenzie and Bromley dealt with the use of gold–germanium junctions as proportional particle spectrometers having a fast rise-time (< 3 mμsec.).

The exhibition was very well staged and paid due attention to research and up-to-date development as well as more conventional technology. The many pieces of equipment using transistors illustrated well their versatility and wide field of application. The exhibition showed also the extent to which industries ancillary to semiconductor technology, producing equipment such as furnaces, radio-frequency heaters, air-conditioning equipment, control instrumentation, etc., and supplies of high-purity material, are springing up. Among the newer semiconductor devices were mesa transistors from the United States and four-layer controlled rectifiers, and among the applications was a high-speed sampling oscilloscope exhibited by the Atomic Energy Research Establishment. The University of Birmingham showed experimental work on space-charge-limited currents in cadmium sulphide crystals. Associated Electrical Industries Research Laboratories showed some of the results of their investigation of etch-pits and other surface defects on germanium and silicon crystals, and of the diffusion of aluminium towards dislocations in silicon crystals.

This Convention was not intended as a continuation of the Reading–Amsterdam–Garmisch–Rochester series sponsored by the International Union of Pure and Applied Physics, but rather as one to bring together the specialists from among the makers and users of transistors. It had something in common with the germanium and silicon materials and devices sessions of last year's Brussels conference. It is, however, to be hoped that the organizers of future conferences on transistors and related devices will take note of the very real risks of devaluation of the meetings caused both by overloading and by dilution of the programme with material that is either not pertinent enough or novel enough to those (generally already more or less expert in the subject-matter) most likely to benefit from the discussions.

F. F. ROBERTS
H. G. BASSETT

NEW MEDICAL-SURGICAL BUILDING OF THE ONTARIO VETERINARY COLLEGE

THE new medical-surgical building of the Ontario Veterinary College was opened recently by two ministers of the Province, the Minister of Agriculture, the Honourable W A Goodfellow, and the Minister of Public Works, the Honourable T R Connell In Canada and the United States there is a division of responsibilities for certain service between the federal and the local government, and in both countries education is a local responsibility and provided by the Province or the State The College was founded in Toronto as a private institute in 1862 by Andrew Smith, a graduate of the Royal Dick Veterinary College in Edinburgh, and was acquired by the Government of Ontario in 1908 It was affiliated to the University of Toronto at that time and was transferred to Guelph in 1922 The present dean, Dr T Lloyd Jones, a Welsh-born Canadian, was appointed in 1952 Dr Jones has done a great deal to improve the teaching and research facilities of the College He is interested in the broad field of veterinary education, has travelled in the United States, South America, India and Europe, to study this subject and has acted as a consultant on international problems in veterinary education

The new buildings provide incomparable facilities for teaching clinical subjects , the older accommodation has also been retained for housing animals for disease investigation, thus greatly increasing the available animal space To provide a similar building in Britain would cost about one million pounds Facilities for teaching the preclinical subjects are provided on the same generous scale, and it is proposed to re-house some of these departments in the next few years Generally, the veterinary schools in North America are on a more lavish scale than those in Britain At Guelph the new accommodation brings the college to a very high level even by American standards There is only one other college in Canada, at St Hyacinthe, Quebec, where instruction is given in French

The College is affiliated to the University of Toronto, but its administration is vested largely in the dean and the Veterinary Faculty, with responsibility to the Ministry of Agriculture Courses of study are submitted to the Senate of the University of Toronto As a result of the growing demand for university education in Canada, the educational institutes at Guelph may, in the not too distant future, attain full university status If this takes place it would be a reversal of the pattern so common in Britain where arts and humanities so often precede the science subjects Guelph would be unique in having veterinary science as its oldest faculty, 1862, followed by agriculture twelve years later This latter has developed into a very large faculty comprising large units for each of its component subjects Guelph and Toronto are about sixty miles apart, but this distance has not prevented close collaboration between members of the medical and veterinary professions in a number of research subjects For many years there has been a close liaison between the Department of Physiology of Toronto Medical School and the Surgery Department of the Veterinary College In the more recent past a joint team of medical and veterinary workers has carried out an investigation on atherosclerosis and studied the effect of certain phospholipids in experimental work on pigs

The new building is constructed in red rustic brick and modern building materials have been utilized in the floors, walls and ceilings, each suitably selected for function but designed in such a way that æsthetics and function combine to form a most attractive building Those who planned the buildings studied the layout of a number of clinical departments They were able to avoid the faults which experience had brought to light in several schools There are several operating theatres equipped for large animals and a number of small animal theatres all serviced by central sterilization The X-ray equipment is specially designed for large animals and has special Buckie screens for use with horses and cattle A large therapy unit is also available Housing has been provided for all types of animals, and the small animal unit is up to the standard of a modern hospital and is air-conditioned throughout

In meeting the cost of this magnificent new building the Provincial Department of Agriculture has recognized the great contribution that can be made and has been made by the veterinary profession on an increasing scale to the economy of the country This type of clinical department is particularly essential in veterinary schools where the teaching material cannot be provided in existing hospitals

Eleventh Annual Convention of the Canadian Veterinary Medical Association

The Convention, held in the Ontario Veterinary College, was attended by more than six hundred veterinarians from Canada, the United States, Great Britain, South America and the Caribbean area The visitors included practitioners, federal and provincial workers, and those interested in research, education and public health Meetings were held in the new hall and in the Agricultural College buildings In a presidential address, Dr J N Henderson, professor of clinics, expressed the view that great changes were taking place in agriculture, that farming was no longer a way of life but was becoming a means of earning a living and that small units would have to merge to form a unit that would give a financial return comparable with other occupations The veterinary profession would have to train graduates who were fully aware of economic factors in animal production and be able to provide an appropriate professional service

There were papers on many aspects of modern surgical techniques in large and small animals and an up-to-date review of the application of radiology to veterinary practice Fundamental aspects of bacteriology and virology were discussed, and papers dealt with the zoonoses with particular reference to government participation in schemes of control The role of the profession in the civil defence programme was outlined The structure of the poultry industry in North America has changed radically during the past ten years and the role of the profession in these new circumstances was discussed While there is a general acceptance that the medical and veterinary professions have a great deal in common in teaching and research, the main divergence arises at the point of application to their respective patients Economic considerations are of greatest influence in the poultry industry, where a setback in rearing birds may represent the difference between a profit and a loss , there are similar considerations with all the farm animals and it is only with pet animals that sentiment replaces economic considerations The diverse problems arising in controlling rabies were discussed and a film was shown of clinical cases of rabies in dogs, cats and cattle In North America there is a reservoir of infection in wild life—foxes wolves, skunks—and relatively few cases in dogs In Trinidad there is a vastly different problem where vampire and other bats act as reservoirs and the epizootic pattern in cattle varies with the disease position in colonies of bats These colonies break up and disperse when furious rabies develops and causes infection in cattle in new areas In Great Britain dogs and cats entering the country are held in quarantine for six months and it is clear that this is a small price to pay for freedom from this disease There were three British veterinarians present who contributed to the proceedings J N Ritchie, chief veterinary officer of Great Britain, presented a paper which surveyed the present position of the veterinary services in Britain, and W L Weipers, of the University of Glasgow, reviewed developments in veterinary education D D Lawson, of the University of Glasgow, presented a paper on thoracic surgery and gave a televised demonstration of volatile anæsthesia in the cow and the dog

This Convention provides a forum for the discussion of scientific and administrative matters which affect the profession in Canada As Guelph is the alma mater of the majority of veterinarians who live in Canada, the meeting in this city also took on the character of an alumnus reunion and the social functions were very well attended

CONTROL OF GOVERNMENT RESEARCH AND DEVELOPMENT EXPENDITURE IN BRITAIN

THE seventh special report from the Select Committee on Estimates for the session 1958–59* contains the observations of the Treasury on the sixth report from the Select Committee for the session 1957–58 dealing with Treasury control of expenditure (see *Nature*, 182, 1467 , 1958) While the Treasury agrees with the Committee's general analysis and many of its comments on particular points, the Treasury suggests that in some respects the Committee's conclusions imply some misconceptions of what is needed, what is possible and what is in fact done It is claimed that the theory of departmental responsibility and partnership has been steadily pursued under successive Governments for about forty years, and the Treasury does not agree that, while new expenditure may be carefully watched continuing expenditure may escape relatively unchallenged Although the main responsibility for vigilant watching for economy in continuing expenditure rests, and must rest, with the spending Department, the Treasury does in fact supplement the Department's own efforts by maintaining a constant watch on continuing expenditure, as well as by bringing particular areas of such expenditure under special review from time to time A high proportion of the Treasury's time is in fact devoted to considering such continuing expenditure

On the Committee's suggestion that eventual commitments are inadequately assessed, the Treasury points out that a wide degree of uncertainty must often remain as to the eventual cost of research policies or major developments involving the solution of scientific and technical research problems , the comment is made that it is unrealistic to suppose that some alteration of financial technique in the Treasury could avoid such difficulties. Secondly, the Treasury points out that forecasts of all civil expenditure, up to three years ahead, have in fact been prepared annually for many years past, and play a very important part in the general control of Government expenditure Without claiming that the technique of 'forward looks' is yet as fully developed or effectively exploited as it might be, the Treasury points out that Ministers are able to decide how far it is necessary to review existing policies reflected in the forecasts, and to adjust new policies which they may have had in mind, to contain the total of Government expenditure within acceptable limits In devoting further attention to this matter, the Treasury undertakes, however, to have full regard to the Committee's comments Again, while the Treasury agrees generally with the Committee as to the importance of prior sanction control, and also that the limits of delegated authority should be periodically reviewed as is at present done, it does not interpret the Committee's report as recommending in general any major change in the existing policy It agrees with the Committee's view that delegation so far as is compatible with the reservation to the Chancellor of the Exchequer of the power to discharge effectively his own essential responsibilities is primarily an attitude of mind which should lead to action whenever opportunity offers , but the three criteria suggested by the Select Committee in this connexion are regarded neither as a complete guide nor, within the ground they cover, as a wholly reliable one

The Select Committee on Estimates had recommended specifically that a small independent committee, which should have access to Cabinet papers, should be appointed to report upon the theory and practice of Treasury control of expenditure This recommendation the Treasury does not accept, and the report sets forth at some length the reasons why the Government is not prepared to accept the recommendation , although in view of the Committee's observations, the Government is initiating an internal inquiry, to be conducted under the general authority of the Chancellor of the Exchequer, into the principles and practice which govern the control by the executive of public expenditure The conclusions reached by the Government will be reported to Parliament in due course

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* Seventh Special Report from the Select Committee on Estimates, Session 1958–59 Treasury Control of Expenditure (Observations of the Treasury) Pp 16 (London H M Stationery Office, 1959) 1s net

The Treasury recognizes that the operation of Treasury control should be under constant review, but it does not consider that a review by an outside committee would be useful, partly because it would involve, in effect, a review of the Chancellor's conception of his own responsibilities, and partly because it would probably be found that a review of this kind would need to be extended beyond the Treasury itself into Parliamentary practice and into the financial control exercised by each major Department of State The Treasury submits that it would be inappropriate for the Government to seek recommendations on Parliamentary practice from a body independent of Parliament, and that a realistic appraisal of the Government's financial control involves also consideration of the working of the central processes of government It would also be inappropriate, the Treasury believes, for an independent committee to scrutinize and pronounce on the inner counsels of Government or on the resulting decisions, for which the Government is responsible to Parliament alone

Some reservations may be entertained on these points , but so far as the scientist or technologist is concerned, comment may well be left until the committee inquiring into the methods of managing and controlling research and development projects, of which Sir Solly Zuckerman has now succeeded the late Sir Claud Gibb as chairman, reports in due course It should suffice to note meanwhile that the Treasury is very conscious of the need for strengthening and developing on the right lines, the control, whether by the Treasury or by Departments, of expenditure on research and development, and is in broad agreement with the Committee's observations on these matters Discussions of which the subcommittee was informed in evidence have already resulted in agreed arrangements, which it is hoped will prove satisfactory in practice, for the closer association of the Treasury with work on defence research and development programmes

THE U.S. NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL, 1957–58

THE report of the U S National Academy of Sciences—National Research Council for 1957–58 (Washington, D C National Academy of Sciences—National Research Council, 1959), published with the President's review and the report of the Treasurer, covers briefly the work during the year of the eight divisions of the Council, of the United States National Committee for the International Geophysical Year, and of the Office of International Relations and the Office of Scientific Personnel The president, Dr D W Bronk, points out that the operating budget of the Academy is now about 10 6 million dollars, an increase of 3 5 millions on 1956–57, and two-thirds of its direct expenditure came from federal agencies A major undertaking (at the request of the Air Research and Development Command) of the year was a study of the scientific and technological future of the Air Force, while the Council's Highway Research Board is now responsible for conducting the American Association of State Highway Officials Road Test at a cost of more than 20 million dollars The Committee on Meteorology, formed two years ago, has completed its study of how meteorology could be furthered, with reference to the needs of the Weather Bureau, and has proposed the establishment of a National Institute of Atmospheric Research During the year a Committee on Oceanography was organized and the Division of Mathematics, with the assistance of the National Science Foundation, completed its survey of research potential and training in the mathematical sciences At the request of the Secretary of Commerce the Academy is organizing a committee to evaluate the functions and operations of the Department in relation to national needs, with especial reference to the National Bureau of Standards, the Weather Bureau, Patent Office and Office of Technical Services

Among miscellaneous activities of the Council not assigned to a division, the report notes those of the Advisory Board on Education, which has given special attention to improving the education of teachers and to studies of science curricula and courses, the committees concerned with the study of the biological effects of atomic radiation, the establishment in February 1958 of a Committee on Polar Research and the work of the Space Science Board, which held its first meeting in June 1958, and is studying the opportunities for scientific research opened up by the advent of modern satellites and rocket tools and their needs

To a certain extent, some of the activities described in this report, such as those of the United States National Committee for the International Geophysical Year and the Office of Scientific Personnel, are covered by the annual report of the National Science Foundation, from which they received financial support and need not here be further described Of those of the Research Council's own eight divisions a few examples are selected for illustration The Division of Anthropology and Psychology participated in some cross-disciplinary projects including a contract with the Air Force for a study of problems connected with bio-astronautics, under the supervision of the Division of Medical Sciences, and a conference on Psychological Research in Education It is also administratively responsible for the Armed Forces–National Research Council Committee on Vision The Division of Biology and Agriculture reports no new major projects The Division of Chemistry and Chemical Technology at its annual meeting was concerned with international chemical affairs and the improvement of documentation in chemical literature but reports no outstanding activities of its units

The Division of Earth Sciences rendered advisory services to the Federal Government through its committees and also conducted the Arctic Sea Ice Conference in February 1958 at the request of the Government. The Division of Engineering and Industrial Research provided advisory services over a wide field of increasing importance and complexities, including such matters as electrical insulation, fire research, highway research, building research, prosthetics research. The Division of Mathematics appointed two new committees, one on statistics and the other to report both to the Division and to the Advisory Board on Education, on mathematical films and television. The Division of Medical Sciences initiated a new project in medical genetics, which will establish a large roster of veteran twins, diagnosed as to zygosity, as well as other studies of rheumatoid arthritis, lesions of the lumbar disk and Japanese *B* encephalitis. The interest of the Sub-committee on Trauma continued to centre on the treatment of burns particularly those involving the respiratory tract. The Division also participated in the establishment of the Inter-departmental Committee on Blood Programme Research and through its Committee on Sanitary Engineering and Environment the Division is increasingly concerned with toxicological hazards arising from the rapid introduction of many new types of material into industry and into the home. The Committee on Tissue Transplantation sponsored a symposium on serological immaturity and agammaglobulinæmia and non-specific forms of lowered resistance to transplanted tissues, including the effects of radiation and cortisone. A primary aim of a revised programme of the Committee for Research into the Problems of Sex is the encouragement of young investigators interested in careers in the field of behavioural research.

The Division of Physical Sciences reports a balance between activities in response to requests from the scientific community and in response to Government requests and between those in physical science and in applied science. Its Committee on Nuclear Science continued to be the largest and most active. Its services to the Government included those of the Committee on Undersea Warfare and the Mine Advisory Committee, and the critical review of Air Force research and development planning noted above and a review of the activities of the National Bureau of Standards.

CLERICAL SALARIES IN BRITAIN

THE eighth of the Office Management Association's surveys of clerical salaries embraced a sample of almost ninety thousand clerks[*]. For the most part, these were employed in private commercial, industrial and professional offices. In addition, one part of the survey related to clerks employed in the public service, nationalized industries, and the joint stock banks. In one form or the other, therefore, the survey supplied information about the salaries of clerks in all parts of the British economy.

Women clerks formed 64 per cent of the clerks in the sample. This compares with the 67 per cent of women among the clerks employed in the corresponding industries in 1951 when the last census of population was taken.

The clerks were employed in a wide variety of British industries but some industries were better represented in the sample than others. ceramics, glass and cement, etc.; chemicals and allied trades; metal manufacture; engineering, shipbuilding, and electrical goods; textiles; food, drink and tobacco; other manufacturing industries were well represented by samples amounting to 10 per cent or more of the clerks employed in industry. The very large number of clerks employed in vehicle manufacture, distributive trades, and in professional and miscellaneous services, were represented by samples of less than 5 per cent. There had been no change since earlier surveys in the proportion of clerks employed on work of this kind. For the men this proportion was only 60 per cent; but 83 per cent of the women were in routine jobs.

On the whole, male clerks' salaries have risen between 12 and 16 per cent in the past two years and those of women clerks between 11 and 13 per cent. The exceptions to this pattern are male clerks doing the lowest grades of routine jobs, whose salaries have risen by between 16 and 27 per cent and the women doing the lowest grade of routine jobs, whose salaries have risen by 14 per cent (clerks under twenty years) and 17 per cent (clerks over twenty years). As the index number of retail prices has risen by 7 per cent during the same period, the real salaries of the clerks have gone up between nearly 5–9 per cent for men and 4–6 per cent for women. Superimposed on this general increase is a large rise for clerks doing the lowest routine jobs.

Manual workers' wage rates during the period from February 28, 1956, to the same date in 1958 rose by just over 11 per cent. Clerical salaries, therefore, rose as much as, or more than, the wage rates of manual workers during the past two years. Wage rates do not, however, tell the whole story concerning manual workers' share of the national economic cake; the fluctuations in their earnings may differ quite considerably from the fluctuations in wage rates. No similar complication affects clerical salaries to anything like the same extent.

It appears, nevertheless, that clerks have in this period done rather better than manual workers in the continuous process of redistributing income. This comes after a decade in which male clerks have been losing ground to manual workers.

Increases have been proportionately less for clerks engaged on more senior and responsible work. Many have scarcely had any increase in salaries at all over and above that accounted for by the fall in the value of money. Because the salary increases during the past two years have been proportionately slightly less for women than for men, the gap between the salaries of men and women clerks doing similar work has widened a little since 1956.

The United Kingdom does not form a single market for clerical labour and even nation-wide employers of clerks recognize this, at least to the extent of introducing London allowances into their national scale. These scales and allowances may be administratively convenient, but the pattern of local clerical markets is more complex than the simple one of a London market and a provincial market assumed by most national employers. The areas of the highest salaries were mainly those having the prosperous engineering, shipbuilding, food-processing and chemical industries in good measure with a high proportion of export trade. It is reasonable to assume that the pattern of clerical salaries for adult male clerks followed a pattern of economic prosperity.

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[*] Clerical Salaries Analysis, 1958. (Office Management Association, 58 Victoria Street, London, S.W.1.) 42*s*.

London comes fairly low down on the scale. Within Greater London there was only one district—the West End—where salaries were comparable with those on Merseyside. This is in contrast with the usual assumption that salaries are generally higher in London than in the rest of the country.

The pattern of variations of salaries for women clerks is simpler and more in accordance with traditional ideas. Greater London was the area of high salaries; the other conurbations had noticeably lower salaries with little to choose between them in contrast with the experience of men clerks in this area.

HELP FOR THE ARTS

ALTHOUGH the full policy of the Calouste Gulbenkian Foundation of Lisbon includes the fields of science, art, education and charity, it now announces that it is prepared to implement the suggestions in a report just issued[*]. This means that for the next three or four years the emphasis of the activities of the Foundation in the United Kingdom will be almost exclusively in the field of the arts.

The report, prepared by a small informal committee consisting of Lord Bridges (chairman), the Countess of Albemarle, Mr. Noel Annan and Sir George Barnes, is the result of their deliberations to help the Foundation by a review of the needs of the arts in Britain. After a few discussions in London the committee visited Bristol, Cardiff, Glasgow, Liverpool, Newcastle upon Tyne and Nottingham. Information was also supplied by a hundred local authorities and by all the universities.

Probably the most striking and indeed definite conclusion is that the arts need help in the provinces to a far greater extent than they do in London. Another point is that far greater support is needed for the arts than in the past and also that this is not a temporary need. This means that in the future public authorities will have to find more money for the arts. It is also stressed that far more needs to be done to-day to render the arts accessible, that there should be more scope for experiment in order to invigorate the arts and that more should be done to foster appreciation among the young. If, as the committee believes, the Foundation can do its best service by stimulating art in the provinces it is pointed out that although under the Local Government Act of 1948 local authorities are permitted to spend up to a 6*d.* rate each year on any form of entertainment it is ascertained that over the whole country expenditure does not exceed ¾*d.* rate for museums and art galleries and ⅕*d.* for music and drama. The members of this informal committee consider that the universities could and should do much more for the 'practice' and encouragement of the arts. Traditionally, this has been left to university societies and thus is outside the scope of the university patronage.

In discussing the specific ways in which the Foundation can help, it is stressed that it should be prepared to back individuals—and to encourage and foster new developments or growing points, feeling that eventually they will be self-supporting and attract permanent support from public funds or elsewhere.

Museums and art galleries receive much consideration, and although the committee welcomes the increase in grants recently announced it is suggested that pictures accepted by the Treasury in lieu of death duties should in certain cases pass to the provincial galleries. This involves the acceptance of pictures perhaps not of exceptional importance but of great interest to a local gallery. It is also felt that although museums have done much good work in developing school services they seem to have lagged behind the expansion in other educational fields. A more active policy of loans between museums is advocated, and for this a general survey of material in the collections is essential. This also leads to the establishment of an improved conservation service. It is also suggested that the Foundation might help to buy works of art for provincial galleries.

In conclusion, the committee considers that Great Britain is producing artists of the highest quality, but adequate support or patronage is lacking. It is to be hoped that the Foundation gives a speedy implementation to the suggestions in this report and then in good time turns to the support of the sciences in Great Britain.

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[*] Help for the Arts: a Report to the Calouste Gulbenkian Foundation. Pp. 64. (London: Calouste Gulbenkian Foundation, United Kingdom and British Commonwealth Branch, 1959.) 3*s.*

DIETARY FACTORS IN THE HOMOGRAFT REACTION

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EXPERIMENTS carried out in 1955 with five strains of mice maintained at this Institute showed that ovarian autografts established themselves regularly and became endocrinologically active within an average time of 10–11 days. In three of the strains intra-strain homografts behaved similarly during the four-week period of observation. In the other two strains, intra-strain ovarian homografts took and survived less well than autografts. Inter-strain ovarian grafts took moderately in some combinations, but rarely survived for four weeks[1].

Repetition of some of these experiments two years later showed that there had been a marked increase in resistance to intra-strain grafts. In the three strains re-investigated (*TO*, *PA* and *WT*) 25/27 of such grafts had taken in 1955, and 19 had survived in a functional state for four weeks, whereas in 1957, 15/29 took and 7/29 survived the test period. Various other experiments with gonad grafts in mice and rats made at the Institute about this time also suggested that there had been an increase in homograft reaction.

Review of the animal husbandry showed only one factor of likely significance: the staple cubed diet (diet 41) had been modified by the substitution of vitamin concentrate and molasses for cod liver oil (diet 41*B*)[2], and an investigation was therefore started to find out whether such a change could have affected the homograft reaction.

The technique was as described previously[1]. Young adult females were spayed, the ovarian capsule, the Fallopian tube and the top of the uterus all being removed to minimize the possibility of ovarian regeneration. The ovaries from donor animals were dissected free of adnexa, cut into two pieces and implanted under the skin of the flank. The establishment of an active graft and its survival time were determined by the re-occurrence of cornified cells in the vaginal smear.

The first experiment was to make a new batch of diet 41, so that a direct comparison could be made between mice maintained on it and on diet 41*B*. For this purpose, *PDE* mice, a sub-strain of *PA* mice, were used; these were known to show a vigorous intra-strain homograft reaction (10/30 grafts established and 3/30 surviving 4 weeks). *PDE* breeding mice were maintained on diet 41 for some months and then the intra-colony homograft reaction in 40 females drawn from this colony was compared with that in 40 females of the same strain maintained on diet 41*B*. The results are shown in Table 1.

Table 1. THE INTRA-STRAIN HOMOGRAFT IN COLONIES OF *PDE* MICE MAINTAINED ON DIET 41 AND ON DIET 41*B*

Diet	No. of females receiving implants	No. of females developing active grafts	No. of females with active grafts at 28 days
41	40	28	13
41*B*	40	13	4

The difference in the number of mice developing active grafts was significant at the $P = 0·01$ level and substantiated the idea that the change in homograft reaction between 1955 and 1957 had been associated with the change of diet. The results of a small series of inter-colony grafts were concordant with the presumption that the difference in homograft reaction originated in the recipient rather than in the tissue grafted.

Attention was then turned to the nature of the dietary factor involved in modifying the homograft reaction. Diet 41 had been abandoned because of the destructive action of the cod liver oil on the vitamin E. It was thought, therefore, that treatment of 41*B* with excess of cod liver oil might abolish its effect in augmenting the homograft reaction. Results with 20 mice, however, gave no support to this idea; but the result cannot be regarded as conclusive, because the unpalatability of the treated diet 41*B* prevented an adequate preparation period.

At this stage, my colleague Dr. J. H. Humphrey directed my attention to the work of Axelrod and others, who had investigated the effect of various dietary factors on immunological response and who had found that pyridoxine-deficiency, whether induced by deficient diets or pyridoxine antagonists, notably depressed antibody formation[3,4].

On the basis of these reports plans were made to test the homograft reaction in pyridoxine-deficient animals. In a first experiment, 10 *PDE* mice maintained on diet 41*B* were injected daily with 0·25 ml. saline and a similar group with 0·25 ml. saline containing 2·5 mgm. deoxypyridoxine. After four weeks, intra-group ovarian homografts were made, treatment being continued. After another four weeks, 5 of the 9 surviving antagonist-treated animals retained active grafts, but only one of the 10 control mice. This result, although not itself of great statistical significance, was distinctly encouraging and more extensive experiments were carried out on mice receiving homografts after preparatory treatment for four weeks with deoxypyridoxine added to the drinking water in amounts calculated to give an intake of 2·5 mgm. or 5·0 mgm. per day. Results are summarized in Table 2, and indicate that the oral administration of deoxypyridoxine to the recipient markedly increased the survival-rate of ovarian homografts. 5 mgm. daily was not detectably more effective than 2·5 mgm., and was appreciably more toxic in that 7/30 of the animals died during the experiment. The effect on the survival of homografts was abolished by the administration of pyridoxine during the second half of the preparatory period and was therefore due to pyridoxine-deficiency rather than to some side-effect of the antagonist. When re-examined after 3 months, 10/36 of the mice treated with deoxypyridoxine only retained active grafts compared with 0/37 in those receiving deoxypyridoxine plus pyridoxine.

Table 2. TAKES AND SURVIVAL OF INTRA-STRAIN HOMOGRAFTS IN *PDE* MICE MAINTAINED ON DIFT 41*B* WITH AND WITHOUT DEOXYPYRIDOXINE

Preparatory treatment for 4 weeks	Proportion of animals developing active grafts	Proportion of animals with active grafts at 28 days
None	10/30	5/30
2·5 mgm. per day deoxypyridoxine	17/20	12/20
5·0 mgm. per day deoxypyridoxine	19/23	14/23
2·5 mgm. per day deoxypyridoxine	26/38	17/38
2·5 mgm. per day deoxypyridoxine + 1 mgm. pyridoxine per day for last 2 weeks	13/38	2/38

Experiments were then extended to inter-strain homografts, *TO* females receiving ovarian implants from *PA* females. The results are shown in Table 3.

Pyridoxine deficiency is therefore almost as effective in preserving inter-strain as intra-strain homografts, and as with the intra-strain grafts the higher dose did not appear to be more effective. Re-examination of four groups of the treated animals at the end of three months showed that 9/30 retained active grafts.

Table 3. TAKES AND SURVIVAL OF INTER-STRAIN HOMOGRAFTS IN RECIPIENTS WITH AND WITHOUT DEOXYPYRIDOXINE

Preparatory treatment for 4 weeks	Proportion of animals developing active grafts	Proportion of animals with active grafts at 28 days
None	4/20	0/20
2·5 mgm. deoxypyridoxine per day	18/28	12/28
5·0 mgm. deoxypyridoxine per day	9/15	5/15

Table 4. SURVIVAL OF RAT OVARIAN TISSUE GRAFTED INTO PYRIDOXINE-DEFICIENT MICE

Preparatory treatment for 4 weeks	Strain of mouse	Proportion of animals developing active grafts	Proportion of animals with active grafts at 28 days
None	*PA*	11/40	0/40
2·5 mgm. deoxypyridoxine per day	*PA*	10/37	6/37
None	*PDE*	9/19	0/19
2·5 mgm. deoxypridoxine per day	*PDE*	28/40	12/40

Striking results were obtained with heterografts of rat ovaries made into treated mice (Table 4).

In the third group of mice the surviving grafts were removed by operation after five weeks and were found to be relatively very large and, although heavily infiltrated with leucocytes, were found on histological examination to possess numerous follicles and corpora lutea. In general, these heterografts were very different from the few small degenerate specimens which can be found in untreated mice at five weeks after the subcutaneous implantation of rat ovarian tissue.

The effect of pyridoxine deficiency in depressing the reaction against ovarian homografts is greater than that of a single dose of whole-body irradiation in mice[5] and of the same order as that which can be obtained in rats by pre-conditioning the prospective recipient with suspensions of homologous tissue[6]. It is less permanent according to present experience than the effect which can be obtained by the induction of tolerance early in life[7].

While these experiments were in progress, Axelrod and his collaborators[8], in continuation of their earlier work, published the results of experiments on intra-strain skin grafting in pyridoxine-deficient rats. In two strains of rats they found that the percentage of takes in deficient rats was far higher than in normal ones, and in one strain survival at 10 weeks was also far better. Experiments on man, however, failed to give analogous results, possibly because the degree of pyridoxine-deficiency was inadequate[9].

So far as rats and mice are concerned, however, it seems clear that the reaction against skin and ovarian homografts respectively is much reduced by pyridoxine deficiency. According to Axelrod *et al.*[8], "it is possible that this effect is related to an inhibition of the immune response to the antigens of the donor skin in this deficiency state". With this suggestion, it seems desirable to postpone discussion until more facts are available.

My thanks are due to Dr. J. H. Humphrey, Dr. H. R. V. Arnstein and Miss H. M. Bruce for advice, and to Miss M. P. G. Moylan and Miss B. M. Flannelly for technical assistance.

[1] Parkes, A. S., *J. Endocrinol.*, **14**, xxi (1956).
[2] Bruce, H. M., and Parkes, A. S., *J. Animal Tech. Assoc.*, **7**, 54 (1956).
[3] Axelrod, A. E., and Pruzansky, J., *Vitamins and Hormones*, **13**, 1 (1955).
[4] Stoerk, H. C., Eisen, H. N., and John, H. M., *J. Exp. Med.*, **85**, 365 (1947).
[5] Parkes, A. S., *J. Endocrinol.*, **16**, x (1958).
[6] Parkes, A. S., *Transplant. Bull.*, **5**, 45 (1958).
[7] Martinez, C., Smith, J. M., and Good, R. A., *Brit. J. Exp. Path.*, **39**, 574 (1958).
[8] Axelrod, A. E., Fisher, B., Fisher, E., Lee, Y. C. P., and Walsh, P., *Science*, **127**, 1388 (1958).
[9] Fisher, B., *Transplant. Bull.*, **6**, 432 (1959).

DIAPHRAGMS FOR ANALYSING THE DEVELOPMENT OF CONNECTIVE TISSUE

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TO gain fundamental information about the nature of any complex biological structure or process, we have to develop techniques which permit us to analyse it by breaking it down into its constituent elementary units ; the dissection of organs, the preparation of pure microbial or tissue cultures are examples in point. The study of the laws that govern the developmental mechanics of connective tissue (for example, during normal growth, wound healing and inflammation) has been greatly handicapped by the lack of techniques suitable for an analysis of this kind. Normally, the cells and intercellular structures of connective tissue form an extremely complex maze. Even the simplest linear wound elicits a multitude of interdependent regenerative processes the elements of which (exudate, fibrin, fibres, cells, vessels) interlace in all directions, so that a study even remotely resembling an 'elementary analysis' of the constituents becomes virtually impossible. Accordingly, the scope of the conventional techniques for the study of connective tissue is necessarily limited to the description of histological or chemical components, the uptake of vital dyes, the speed of cicatrization, the measurement of tensile strength, etc.

The object of this communication is to describe the design of diaphragms which, when introduced into connective tissue, present it with simple problems of organization, in that they block growth except along one, or more, regular, predetermined channels. Thus we can obtain single beams of connective tissue, or cords intersecting at any desired angle ; these, like the parallel beams of light produced by optical diaphragms, lend themselves to reveal the underlying order in an otherwise confusing complexity.

All experiments were performed on female Sprague–Dawley rats, with an initial body-weight of 100–150 gm. The sterilized diaphragms were introduced beneath the shaved dorsal skin, under ether anæsthesia. Groups of rats were then killed at weekly intervals, to examine the progress of organization macro- and microscopically.

Analyser diaphragms may be prepared of various materials (plastics, china, rubber, paraffin-coated paper, etc.), but glass is the most satisfactory : it can easily be shaped, chemically cleaned and sterilized, its hard, smooth surface prevents adhesion of tissue to the wall, and its transparency facilitates examination of the contents.

Fig. 1 illustrates a few of the basic patterns of tissue-diaphragms that were employed for analysis.

The simple tube, open at both ends (Fig. 1*A*, *B*, *C*), permits only unidirectional growth, in the form of a

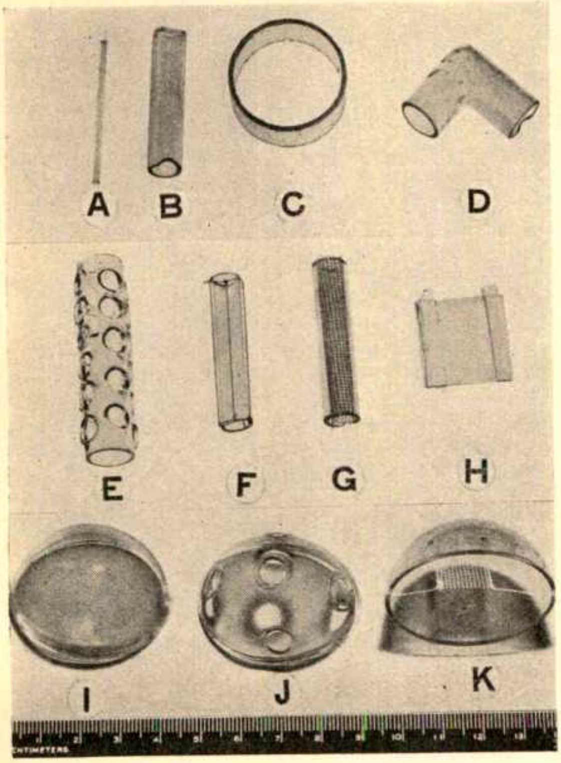

Fig. 1. Samples of various tissue diaphragms

connective-tissue cord that connects the two orifices. The length and calibre of the tube vary in accordance with the problems to be studied; capillaries and small-bore tubes have the additional advantage of being readily implantable, not only into loose connective tissue, but also into muscles, pleura, peritoneum and various parenchymatous organs. Tubes with one end closed revealed that a minimum of two 'tissue bridgeheads' is necessary for rapid organization of a gap, while L-shaped (Fig. 1*D*) and branching tubes (in the form of a Y, T or +) are employed to examine the formation of anastomosing tissue cords at predetermined angles. One perforation or more in the wall of the tube (Fig. 1*E*) offers additional possibilities for the establishment of tissue connexions within a single cylinder (that is, unguided by restraining individual tubular walls around each tissue-cord). Simple, straight tubes, open at both ends, containing a central nylon thread (Fig. 1*F*), an inner parietal lining of fine nylon trellis (Fig. 1*G*), or a central flat 'ladder' of nylon trellis that connects the two open ends revealed that this additional internal scaffolding is especially effective in accelerating organization along the threads. Organization is also expedited by enveloping the diaphragms in nylon trellis; the rapid invasion of the latter by connective tissue furnishes a stabilizing capsule for the whole object. Double plates (two cover-glasses, their surfaces slightly separated by lateral glass ledges) offer the possibility of studying two-dimensional invasion of a flat space (Fig. 1*H*); the tissue formed in this can then be examined by merely placing the entire object under the microscope. Hemispheres, or—because of the shape of the rat's back—hemi-ellipsoids are used to examine factors which influence the three-dimensional organization of rounded cavities. These structures offer no entry to tissue, except at their base (Fig. 1*I*), or have one additional opening or more on the roof (Fig. 1*J*) for the exploration of simple or complex tissue-bridge formation. Finally, minute perforations in the roof (which can afterwards be sealed with a drop of paraffin) make it possible to attach threads or trellises of nylon at any point of the roof, thus connecting it with the base (Fig. 1*K*). It is then possible to explore the effectiveness of the nylon scaffolds as tissue guides.

Fig. 2 shows a hemispherical analysing diaphragm with multiple perforations, under the shaved dorsal skin of a rat, two weeks after implantation. The scar of the incision, through which the object had been introduced (dark spots near the root of the tail), is almost healed; it did not interfere with organization within the diaphragm, because the latter was pushed forward at some distance from the wound to prevent the development of external adhesions and diminish the probability of infection. Owing to the absorption of air from the cavity of the hemisphere, the skin over the perforations is slightly depressed. The depth of these depressions remains limited, however, because, soon after implantation, exudation begins and a characteristic, citrine, thick fluid fills out the empty space. This fluid does not coagulate *in situ*, but has some tendency to do so after evacuation. Eventually, fibrin threads, covered and invaded by histiocytes, connect the parietal openings with the base and thus provide temporary bridges. These are later organized by connective tissue and invaded by blood vessels.

This organization is most clearly illustrated by the simple, unidirectional growth that occurs in straight glass tubes (Fig. 3).

Two weeks after implantation of such a tube (3 cm. long, 0·8 mm. wide, and enveloped in a nylon trellis for better fixation), a straight axial cord has developed between the two openings (Fig. 3*A*). This cord consists of a broad, central spindle made up of fibrin threads and histiocytes. It is attached to the centre of the end-plates by a narrow filament of connective tissue, Van Gieson-positive and well vascularized. By this time, such tubes are completely or almost completely filled with citrine fluid

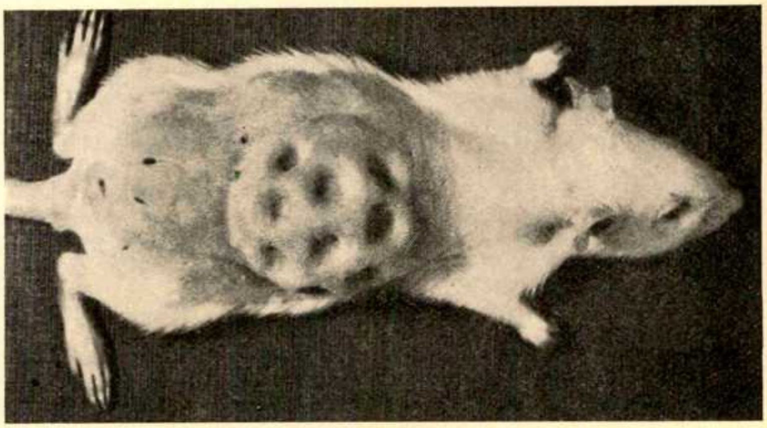

Fig. 2. Hemispherical tissue diaphragm as it appears *in situ*

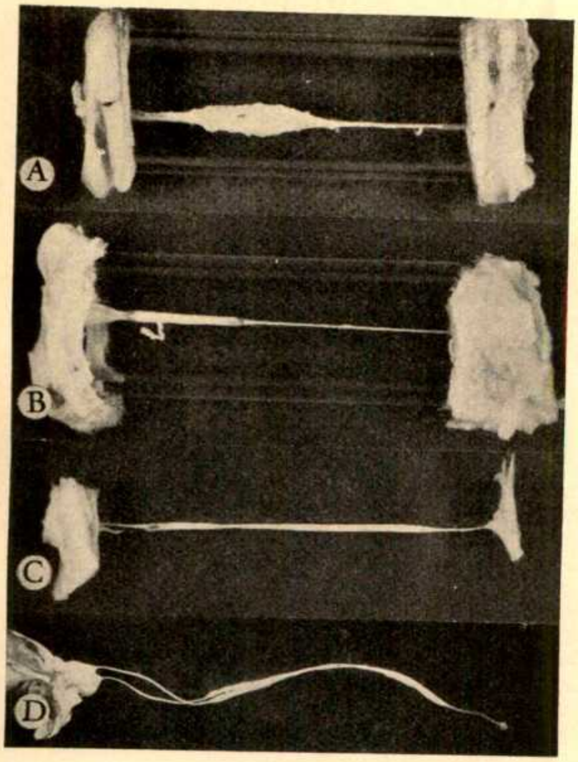

Fig. 3. Various stages and types of axial-cord formation within simple glass tubes. In *A* and *B* the tube and the disk-like connective-tissue plates at the opening are intact; in *C* and *D* the contents are represented after removal from the tube

and, although the two end-plates of connective tissue are broad, the bridge is invariably narrow and attached centrally.

After one month, the fibrin spindle becomes narrower and shorter (Fig. 3*B*); the 'growth line' that separates the light fibrinous centre from the darker invading tissue is reddish in the living animal. Quite commonly, invasion by connective tissue progresses much more rapidly on one side (in Fig. 3*B* on the right) than on the other, but the development of fibrin threads between the spindle and the glass wall (which apparently occurred here because of a rough dirt speck on the wall) is exceptional. It is also quite uncommon to find an accessory, abortive, second cord, attached unilaterally (Fig. 3*C*), or a complete Y-shaped, split cord, in simple straight tubes (Fig. 3*D*). Curiously, within the limits which have been studied so far, the speed with which the two openings are connected by an axial cord, and the thickness of these bridges, are largely independent of the length and width of the glass tubes.

The details of these investigations will be described elsewhere. Here, attention is directed merely to the possibility of analysing the mechanics of tissue growth by the selective restriction of proliferation to certain channels. It is hoped that such analysing diaphragms may prove useful in the study of developmental mechanisms under normal conditions and after the topical or systemic application of growth-modifying stimuli.

These experiments were performed with the aid of grants from the National Cancer Institute of Canada (grant No. 22) and from the Gustavus and Louise Pfeiffer Research Foundation.

ESTABLISHMENT OF PARENCHYMATOUS SPLENO-PULMONARY VENOUS ANASTOMOSIS

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A SUCCESSFUL shunt between the splenic vein and the pulmonary venous system via a parenchymatous anastomosis in the dog has been achieved. The investigation was conducted in an attempt to find a solution to the problem of extrahepatic obstruction of the portal venous system in young children. At present, this condition in children is not as amenable to successful treatment by current methods of shunt operation as in adults. Further work will be necessary before application of this experimental work to clinical problems can be undertaken.

Dogs 8–20 kgm. in weight were used. General anæsthesia was induced and continued with thiopentone and succinylcholine chloride in divided doses, respiration being maintained by manual control of flow of oxygen through an endotracheal tube. Tetracycline was administered by mouth for ten days, beginning the day before operation, to avoid the high incidence of acute empyema which occurred post-operatively in the early attempts.

A thoraco-abdominal incision was made in the line of the eighth rib on the left side, and the spleen delivered through the wound. A bulldog clamp was temporarily applied to the splenic pedicle. Most of the spleen was removed, leaving part of the lower pole, measuring approximately 3 × 2 × 1 cm. at the site of entry of the main lower division of the splenic vessels. The splenic capsule was removed except that on the hilar surface.

Next, a Satinsky vascular clamp was placed across the lower part of the lower lobe of the left lung, to act both as a retractor and as a hæmostat. An incision about 3 cm. long was made in the lung on either the costal or diaphragmatic surface, and continued deep into its substance. After bringing the splenic pedicle up through the tendinous part of the diaphragm, the remnant of the spleen was inserted into the opening in the lung and the lung sewn over it.

All clamps were removed and an intercostal drain inserted and connected to an underwater seal. The wound was closed in layers.

The operation is relatively easy to perform, and the procedure is usually completed in 1–2 hr. The overall operative and post-operative mortality was

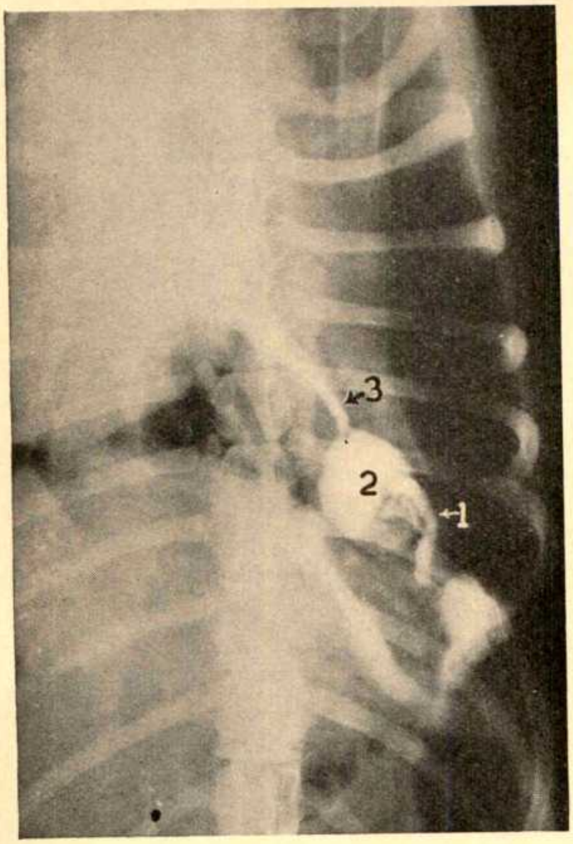

Fig. 1. Venogram showing anastomosis during injection of 'Hypaque –*R*'. 1, Splenic vein; 2, spleen; 3, inferior pulmonary vein

approximately 10 per cent. In the majority of cases, the dogs made rapid recovery and resumed normal activity and appetite within one or two days.

Demonstration of the Anastomosis

Each dog was explored through the original incision 8–10 weeks following the procedure, and the area of anastomosis was examined. It was noted at operation that good pulsation was present in the splenic artery. Most of the left lung was expanding normally, and only a small part of the lower lobe, approximately equivalent to one broncho-pulmonary segment, was firm and thickened.

Demonstration of the anastomosis was made by the following three methods:

(1) *Venography*. The splenic artery and vein were ligated and cut inside the abdomen and a polyethylene catheter was tied into the lienal side of the cut splenic vein. A roentgenogram of the lung was taken during injection of 10 ml. of 50 per cent 'Hypaque' solution.

Fig. 1 illustrates the typical appearance of the roentgenograms in the cases investigated in this way. The dye passed through the splenic vein in a retrograde direction into the implanted spleen and thence via the parenchymatous anastomosis into one of the left pulmonary veins.

(2) *Plastic Preparation*. After excision of the anastomotic area, polyethylene catheters were tied into the left inferior pulmonary vein and into the splenic vein. Simultaneously, liquid neoprene plastic was injected into both catheters at a pressure of 100 mm. mercury, a dark colour into the pulmonary vein and a light colour into the splenic vein. The catheter in the pulmonary vein was removed before that in the splenic vein. The specimen was then

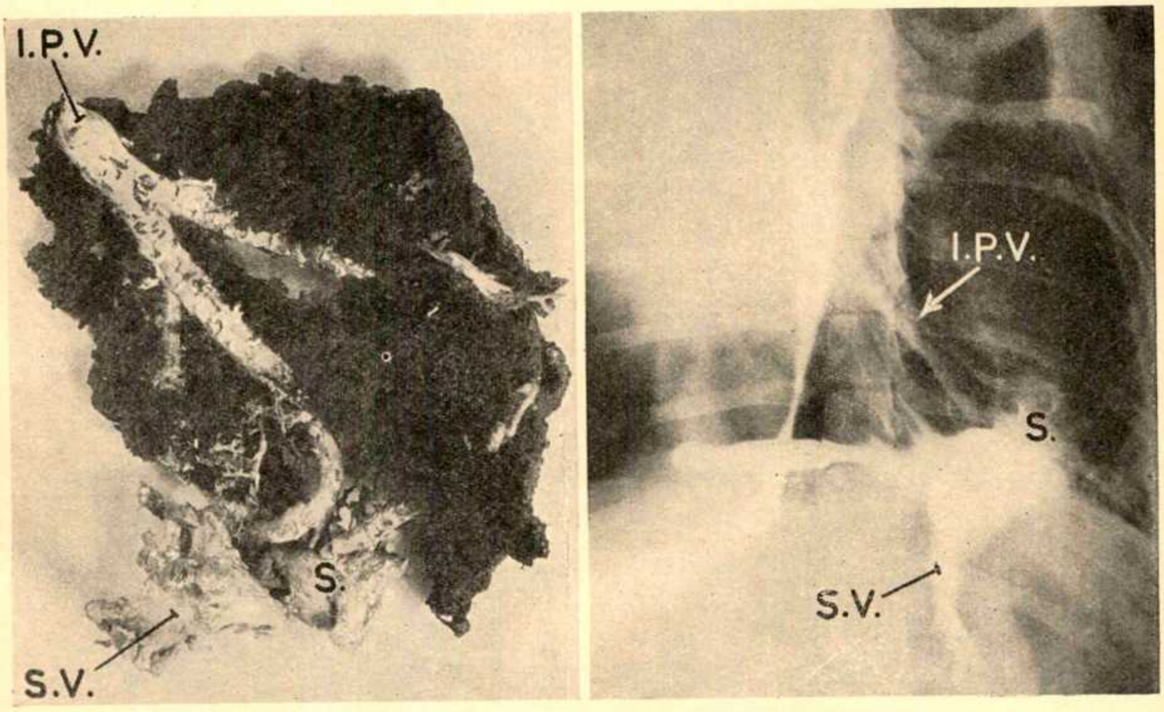

Fig. 2. Plastic cast showing filling of spleen and inferior pulmonary vein following injection into splenic vein. The venogram of the same animal taken during life is also shown for comparison (right). *S.V.*, splenic vein; *S*, spleen embedded in lung; *I.P.V.*, inferior pulmonary vein

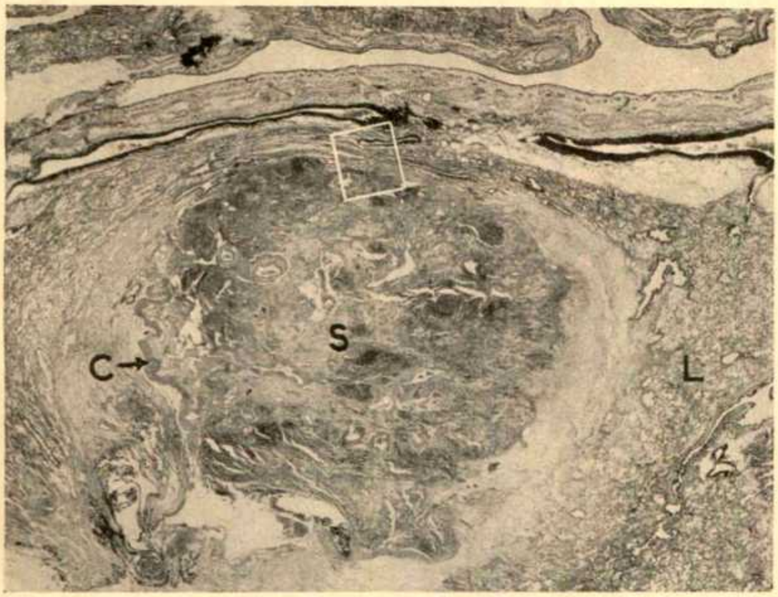

Fig. 3. Low-power view (× c. 6·7) showing the embedded spleen (*S*) and the remnant splenic capsule (*C*) completely surrounded by lung (*L*). (Verhoeff's elastic tissue stain)

immersed in an acid bath which digested the soft tissue and left the solidified neoprene.

Fig. 2 shows filling of the splenic vein, the splenic remnant and the left inferior pulmonary vein with light-coloured plastic. This is in contrast to the dark-coloured neoprene in the small vessels of the lung parenchyma. Fine dissection of the plastic cast showed both colours in all the small vessels of the substance of the lung close to the embedded spleen.

(3) *Histology*. A specimen of lung containing embedded spleen was cut into thin slices and fixed in formalin. Blocks were sectioned serially and stained both by hæmotoxylin and eosin, and also by Verhoeff's elastic tissue and Van Gieson stain.

Fig. 3 shows a cross-section of the embedded spleen in the lung. A small portion of the intact splenic capsule remains while the rest of the spleen merges with the surrounding lung parenchyma. There is increased vascularity in the spleen and a dilatation of the pulmonary vessels surrounding the spleen. Large numbers of vessels are observed just outside the spleen, and dilated vessels are also present in the substance of the spleen (Fig. 4). In some areas a direct connexion between the pulmonary and splenic vessels was demonstrated by serial sections, although no indication of the direction of flow of the blood in the living animal was obtained.

Results and Discussion

In eighteen normal dogs, the spleen was embedded in the lung. Nine of these were examined by methods described above, and in all these evidence was found which was consistent with the establishment of vascular connexions between the two tissues. Of the remainder, five dogs are alive and well, two were operative deaths, and two died of distemper.

In this series of normal dogs a parenchymatous anastomosis between the spleen and the lung has been achieved. The difficulties of producing more than transient portal hypertension in dogs have long been realized, and have been described by Morris[1] as well as others. It was felt that for purposes of this initial study, the existence of portal hypertension in the experimental preparation was not obligatory since if good anastomosis could be obtained in an otherwise normal dog, an even better anastomosis could be anticipated in the presence of portal hypertension.

Further work is being conducted in order to discover the capacity of the anastomosis to dilate and provide a by-pass for an occluded portal vein. Due to technical difficulties, it has not been practicable to measure blood flow through the shunt. It is intended to obtain an approximate estimate of this flow by the use of cine-angiography and by dye-dilution curves. The ability of the shunt to dilate in order to accommodate the increased flow of blood due to portal hypertension is being investigated by performing spleno-pulmonary anastomosis on dogs in which portal hypertension has previously been induced by the method of Kershner[2]. Furthermore, the effects are being examined of applying Kershner's procedures to animals already having the shunt.

Spleno-pulmonary anastomosis, if used in the alleviation of portal hypertension due to extra-hepatic venous block in children, would return portal blood to the left side of the heart. Calculation suggests that this would not overload the heart and would not appreciably affect oxygen saturation in the left atrium.

A parenchymatous surgical approach to the problem of portal hypertension has been described by Felder[3]. He demonstrated vascular connexions between the coapted surfaces of the decapsulated liver and spleen

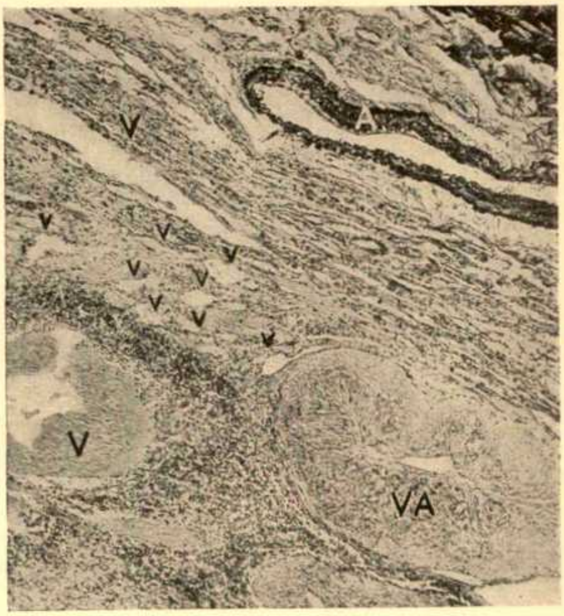

Fig. 4. High-power view (× 60) of area shown in Fig. 3, showing dilated veins in line of fusion of spleen and lung. Veins (*V*), arteries (*A*) and thickening of a vein (*VA*) probably due to anastomosis with a small artery

in rabbits, and showed that this procedure increased the time of survival following ligation of the portal vein.

A procedure in which portal blood was returned to the right side of the heart through an anastomosis between the spleen and intercostal veins has been performed in humans by Turunen[4]. Following the placing of the intact spleen inside the thorax, venous connexions developed between the spleen and the pleura, and bleeding œsophageal varices improved. We suggest that spleno-pulmonary anastomosis as a shunt in portal hypertension should prove superior.

Parenchymatous anastomosis may possibly provide a better method of treatment of portal hypertension in children than the present unsatisfactory procedures.

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[1] Morris, A. N., and Miller, H. H., *Surgery*, **30**, 768 (1951).

[2] Kershner, D., Campbell Hooten, T., and Shearer, E. M., *Archives of Surgery*, **53**, 425 (1946).

[3] Felder, D. A., Haglin, J. J., and Murphy, T. O., *Surgery*, **39**, 7 (1956).

[4] Turunen, M., and Laitinen, H., *Ann. Surgery*, **149**, 443 (1959).

BIOCHEMICAL MECHANISM OF LESION FORMATION IN VIRUS-INFECTED PLANT TISSUES

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THE formation of local lesions is one of the most striking symptoms of virus diseases discovered as early as 1929 by Holmes[1]. Strangely enough, little is known about the metabolic disorders leading to the development of these necrotic spots. They are regarded as 'protective mechanisms' localizing the pathogenic agent to restricted areas of the host tissues due to the total disorganization and breakdown of protoplasmic structure in a small group of host cells highly sensitive to the invading parasite[2]. The local lesions of various host plants attacked by special virus strains and those of resistant wheat plants infected by rust fungi are the most typical examples of lesion formation due to 'hypersensitivity'[3]. Recent ideas concerning the metabolic aspects of defence reactions based on hypersensitivity in resistant wheat plants emphasized the probability that the balance of oxidizing and reducing systems acting on polyphenols is upset in the diseased areas, resulting in the accumulation of toxic polyphenol oxidation products killing the host tissues[4]. Experimental evidence in support of this view has recently been presented by Király[5]. It seemed, therefore, worth while to extend these studies to the problem of virus-induced lesion formation.

The leaves of experimental plants (*Nicotiana tabacum* var. Samsun, *N. glutinosa*, *Datura stramonium*) were inoculated mechanically at an early stage of development (6–8 leaf stage) with tobacco mosaic virus, cucumber mosaic virus or tobacco necrosis virus. When the local lesions appeared (second or third day after inoculation) polyphenoloxidase activity was measured in tissue homogenates by the use of conventional manometric techniques. The catechol–hydroquinone system[6] was chosen as substrate. The results are expressed as Q_{O_2}-values: increase in uptake of oxygen on addition of substrate in mm.^{3} oxygen/mgm. dry matter/hr. As a gradual decrease in activity of polyphenoloxidase was experienced in the course of measurements, results were calculated on the basis of readings taken during the first 10–15 min. Representative examples are given in Table 1.

As shown in Table 1, a considerable increase in activity of polyphenoloxidase was found whenever the host–virus combination resulted in the appearance of local lesions, whereas no similar stimulation was observed when the virus spread systemically, except in a very late stage of systemic infection. This latter observation on systemically infected plants is in agreement with recent findings of Martin[7]. His claims for another smaller maximum of polyphenoloxidase activity in systemically infected tobacco plants at an early stage of infection, however, could not be verified using (to secure reliable controls) the half-leaf method.

Table 1. EFFECT OF VIRUS INFECTION ON THE POLYPHENOLOXIDASE ACTIVITY OF HOST TISSUES

Host plant	Tobacco mosaic virus		Tobacco necrosis virus		Cucumber mosaic virus	
	H	I	H	I	H	I
N. glutinosa	0·2	4·5*	0·2	2·1*	0·2	0·5
N. glutinosa†	—	—	—	—	5·1	9·9
N. tabacum var. Samsun	8·7	9·3	8·7	12·6*	—	—
Datura stramonium	0·6	9·6*	—	—	0·6	1·8

Polyphenoloxidase activity: expressed as increase in oxygen uptake in mm.^{3}/mgm. dry matter/hr. upon addition of substrate.

H, healthy; I, infected.

* Combinations resulting in the development of local lesions.

† Polyphenoloxidase activity tested six weeks after infection. The control was of the same age.

If the accumulation of polyphenol oxidation products, due to an *in vivo* stimulated activity of phenol oxidizing enzymes, were the immediate cause of lesion formation, this latter should be inhibited by the administration of compounds able to reduce quinones or inhibit their formation under physiological conditions. Ascorbic acid is able to reduce quinones chemically. In addition, the inhibitory effect of ascorbic acid on some polyphenolases has been reported[8]. Glutathione and cysteine are also powerful reducing compounds, and *in vitro* inhibition by glutathione and cysteine of the accumulation of polyphenol oxidation products was described[9]. Therefore, the above compounds were infiltrated into detached *N. glutinosa* leaves, the excess of water evaporated, and the leaves infected with tobacco mosaic virus. The infected leaves were then placed with their petioles in test-tubes containing the same solutions and after two days the number of local lesions counted. The results were clear-cut (see Table 2). All the three compounds, if applied in adequate concentration, strongly inhibited lesion formation (10^{-2} *M*). The most effective was ascorbic

Table 2 THE EFFECT OF REDUCING SUBSTANCES ON LESION DEVELOPMENT IN *Nicotiana glutinosa* INFECTED WITH TOBACCO MOSAIC VIRUS

Substance infiltrated	Average number of lesions*	
	Infiltrated	Control
Ascorbic acid 10^{-2} *M*	2	37
Glutathione 10^{-3} *M*	6	42
Cysteine 10^{-2} *M*	5	30

* Average of five consecutive experiments

acid, usually reducing the number of local lesions to zero

This effect is apparently based on a chemical *in statu nascendi* reduction of the quinones formed This is indicated by the fact that a high level of reducing compounds must be maintained in the tissues in order to inhibit lesion development When after infiltration with 10^{-2} *M* ascorbic acid the leaves were placed in water instead of ascorbic acid solution the treatment proved more or less ineffective due to the rapid metabolization of the compound infiltrated Direct measurements (iodometric titration) indicated that the concentration of reducing compounds of the leaves must be raised 7–8 times and maintained at this high level in order to inhibit lesion formation This explains the failure of Wiltshire[10] to obtain the inhibition of lesion development by ascorbic acid in beans infected with tobacco necrosis virus He raised the endogenous ascorbic acid concentration to a lesser extent

The concentration of ascorbic acid applied may be regarded as physiological The inhibition is evidently not due to any unspecific damage to the leaf metabolism since it is reversible Although complete inhibition is achieved by the end of the second day after infection, the lesions will later appear if the concentration of ascorbic acid is allowed to decrease With cysteine and glutathione symptoms of toxicity appeared after about 24 hr To reduce the toxic effect these compounds were infiltrated into the leaves 24–36 hr after infection Even in this case the margins of some leaves were slightly damaged The development of local lesions was, however, arrested in the unaffected areas of the leaf surface as well

The complete abolition of lesion formation in leaves treated with ascorbic acid favours the view that the development of lesions results from an accumulation of quinones due to an enhanced polyphenoloxidase activity and possibly also to a virus-induced breakdown of reducing systems in some cases The disorganization of cell structure in itself does not lead to an increased activity of polyphenoloxidase When leaf tissues of *N glutinosa* were damaged with a needle evoking 'lesions' strikingly similar to those induced by tobacco mosaic virus, the activity of polyphenolases, measured 24 hr after damaging, has not shown any increase comparable to that occurring in leaves with virus-induced lesions This is further evidence to show that the enhanced activity of polyphenoloxidase in virus-infected leaves is a cause and not a result of cellular breakdown and it is actually the mechanism responsible for the hypergic reaction localizing the pathogen and inhibiting its generalization

As judged from transmission experiments the virus did multiply in the treated tissues but this has not led to the appearance of local lesions in the presence of reducing compounds Experiments are in hand to decide whether or not a generalization of the virus occurs in this case

[1] Holmes, F O , *Bot Gaz* , **87**, 39 (1929)

[2] Luria, S E , "General Virology" (John Wiley and Sons, Inc , New York, 1953)

[3] Bawden, F C , "Plant Viruses and Virus Diseases" (Chronica Botanica, Waltham, Mass , 1950)

[4] Farkas, G L , and Kiraly, Z , *Phytopath Z* , **31**, 251 (1958) Farkas, G L , and Ledingham, G A , *Canad J Microbiol* , **5**, 37 (1959) Király, Z , and Farkas, G L , *Phytopath Z* , **34**, 341 (1959)

[5] Király, Z , *Phytopath Z* , **35**, 23 (1959)

[6] Goddard, D R , and Holden, C , *Arch Biochem* , **52**, 380 (1950)

[7] Martin, M C , *C R Acad Sci , Paris*, **246**, 2026 (1958)

[8] Baruah, P , and Swain, T , *Biochem J* , **55**, 392 (1953)

[9] Henze, R E , *Science*, **123**, 1174 (1956)

[10] Wiltshire, G H , *Ann App Biol* , **44**, 249 (1956)

CRYSTALLOGRAPHIC STUDIES OF THE BIURET REACTION

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School of Chemistry, University of Sydney

THE bonding between metal ions and peptides is a subject of increasing biochemical interest Metal-peptide complexes appear to be involved *inter alia* in the transition-states of metal-activated proteolytic enzyme reactions[1,2], in the inhibition of the gelation of gelatine by cupric ions (ref 3 and Kiefer, M , and Vinograd, J R , private communication), and in the formation of the colours of metal-protein solutions[4-8] Hitherto, the evidence for the structures of such complexes has been drawn from measurements on solutions, since insufficient analogy exists between them and the few amino-acid chelates the crystal structures of which have been studied[9-11] We have therefore begun structure determinations of several compounds intended to be models for peptide-metal interaction In this communication we wish to report those features of two of these structures which appear to be of biochemical significance

As a starting-point we have used the well-known fact that, when cupric ion is added to an alkaline solution of a protein or polypeptide, a violet-red colour is produced The reaction is a general one, obviously involves the formation of a metal-peptide complex, and has been used in qualitative and quantitative tests for proteins The violet-red colour is reversibly changed to blue upon acidification of the solution The simplest substance which shows this behaviour is biuret, $NH_2CONHCONH_2$, and the reaction has accordingly become identified with the name of this compound

We have carried out X-ray crystal structure determinations of two substances—potassium *bis*-biuret cuprate(II) tetrahydrate, $K_2[Cu(NHCONHCONH)_2] \cdot 4H_2O$ (substance *a*), and *bis*-biuret copper(II) chloride, $[Cu(NH_2CONHCONH_2)_2]Cl_2$ (substance *b*) The former is the violet 'parent compound' of the biuret reaction It was prepared by shaking fresh cupric acetate with a solution of biuret dissolved in

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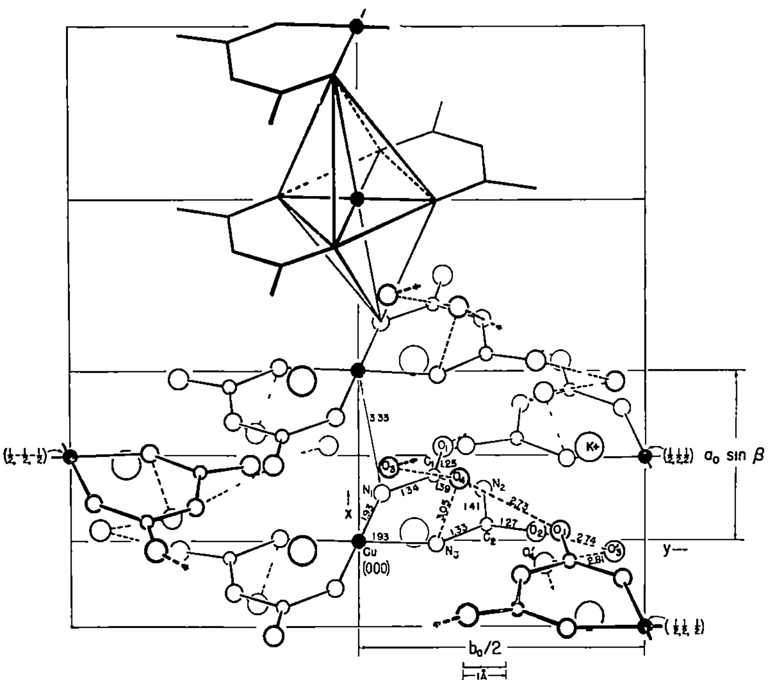

Fig. 1. z-Axis projection of $K_2[Cu(NHCONHCONH)_2]\ 4H_2O$

the calculated excess of aqueous alkali. Crystals were obtained by the slow addition of a large volume of alcohol containing a little potassium hydroxide. The second compound formed tiny pale blue-green crystals when a warm alcoholic mixture of cupric chloride and biuret was gradually cooled. Both complexes were unstable in air but the crystals were adequately protected against decomposition by a thin film of collodion.

Substance *a* is monoclinic *a* = 3·84 A., *b* = 13·32 A., *c* = 13·92 A., β = 94° 5′. The space-group is $P2_1/n$. There are two formula units in the unit cell, and these must therefore be centred about copper atoms at the origin and (½,½,½). Substance *b* is orthorhombic, *a* = 6·83 A., *b* = 8·03 A., *c* = 10·74 A. There are two formula units in the unit cell, but there is an ambiguity between the allowed space-groups *Pnn*2 and *Pnnm*. While the copper atoms are at (0,0,0) and (½,½,½) in either case, only the second of the two possible space-groups would confer centrosymmetry on the complex.

For the violet compound *a* our data consist of the absorption-corrected intensities of about 1,000 X-ray reflexions, visually estimated on Weissenberg diffraction photographs obtained with copper K_α-radiation. The structure has been refined by the method of least-squares, giving a conventional crystallographic reliability factor *R* = 0·079 and standard-deviations of the bond-lengths and bond-angles of about 0·01 A. and 1·6° respectively. The parameters for the anisotropic thermal vibrations of all the atoms (other than the hydrogens) have been computed. The final refinement cycles have produced evidence for the locations of the hydrogen atoms, and it is on the basis of these that we can assign to the compound the formula given above (as distinct from, for example, $K_2[Cu(NH_2CONHCONH_2)_2](OH)_4$). The structure analysis of substance *b* has progressed to the stage where there is no doubt about the general structure. With a single isotropic temperature parameter for all atoms the *R*-factor is 0·127 for 429 *hKl* reflexions (*K* = 0–4), of which one-third were unobservably weak; for those 176 reflexions to which the copper atom makes no contribution, *R* is 0·152. The two structures are shown diagrammatically in Figs. 1 and 2, which are projections along the *z*-axis of *a* and the *x*-axis of *b*, respectively.

The copper atoms are square-co-ordinated in both complexes. In the violet compound *a*, the square-planar arrangement of ligand atoms involves the peptide nitrogen atoms N_1 and N_3 of two symmetrically placed biuret residues. The bonds have reasonable Cu—N lengths of 1·93 A. Successive complexes are stacked at such an inclination to the (100) plane that each nitrogen atom N_1 of one complex also lies exactly at one of the apices of an elongated octahedron about the copper atom of an adjacent complex. The arrangement is illustrated in the upper half of Fig. 1. The distance between the copper and the octahedral nitrogen atoms is 3·33 A., implying that only weak interaction is possible. The closeness of approach between complexes has, of course, a

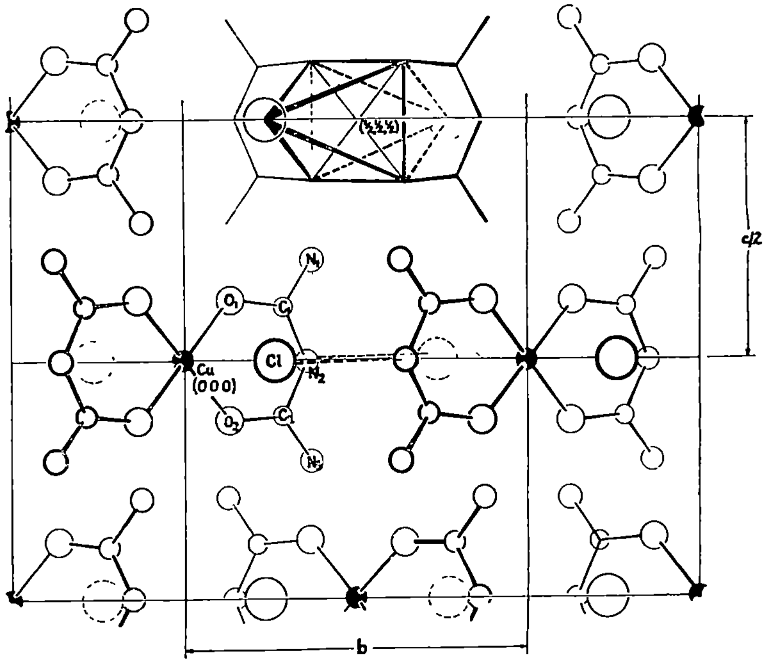

Fig. 2. x-Axis projection of $[Cu(NH_2CONHCONH_2)_2]Cl_2$

lower limit set by the van der Waals' radii It turns out that the Cu—N vector represents the shortest distance between any two atoms of adjacent complexes

The bond-lengths and bond-angles of the amide-groups in *a* are not significantly different from those reported for the biuret molecule in the crystal of biuret hydrate[12] This indicates that the substitution of a co-ordinated copper for an amide hydrogen atom does not seriously disturb the bond-orders and resonance in the amide group As in biuret hydrate, so in *a* the biuret residue is not flat Each biuret residue is bent slightly about the line joining Cu to N_2, the two halves then being twisted in opposite senses about the bonds C_1—N_2 and C_2—N_2 As a result of this distortion there is an angle of about 5° between the normals to the two planes containing, respectively, $N_1C_1O_1N_2$ and $N_2C_2O_2N_3$ Neither amide group lies strictly in the plane of the copper atom and the four attached nitrogen atoms In fact, even if we ignore the non-planarity of the two biuret molecules co-ordinated to a copper atom, the complex is bent by about 2 5° on each side of the co-ordination square along the line adjoining N_1 and N_3 of the ligand

The water molecules and amide groups in substance *a* are linked by a network of hydrogen bonds, albeit not a particularly efficient one If we superscribe the atoms of the complexes centred on $(-\frac{1}{2},\frac{1}{2},-\frac{1}{2})$ and $(\frac{1}{2},\frac{1}{2},-\frac{1}{2})$ with ′ and ″ respectively, then hydrogen bonds link O''_2 O_3, O_3 O_4, O_4 N_3 and O_4 O'_1 The potassium ion fits into a hole in the structure (a fact which does not emerge very clearly from Fig 1), being at the centre of a trigonal prismatic arrangement of four amide oxygen atoms and two water molecules at K^+ O distances between 2 7 and 2 9 A

A closer examination of the configurations about the ligand nitrogen atoms in *a* leads to the important conclusion that considerable distortions from the normal bond-angles may occur at the sites of co-ordination The angles Cu—N_1—C_1 and Cu—N_3—C_2 are both 131° The vector from N_1 to the copper atom of an adjacent complex makes an angle of approximately 90° with both the N_1—Cu and N_1—C_1 bonds The hydrogen atoms which are attached to N_1 and N_3 do not appear to be involved in hydrogen bonds, and their *x*-co-ordinates are not in fact as accurately known as the other hydrogen-parameters in the structure These two hydrogen atoms appear to lie only slightly out of the plane of the copper and nitrogen atoms Approximate values of the bond-angles are Cu—N_1—H, 119° , C_1—N_1—H, 108° , Cu—N_3—H, 112° , C_2—N_3—H, 115° This places the hydrogen atom attached to N_3 on the line between N_3 and the water-O_4 atom of the next unit-cell in the $-x$ direction, although the distance of 3 35 A makes it unlikely that a hydrogen bond is here involved N_3 is, on the other hand, definitely hydrogen-bonded to the water-molecule represented in Fig 1 by O_4 This N_3 O_4 bond lies at angles of 112° and 94° from the bonds N_3—Cu and N_3—C_2

The blue compound *b* also has two biuret molecules bonded to each copper atom via four donor atoms arranged at the corners of a square In this case the octahedral positions are occupied by chloride ions at normal Cu—Cl^- distances of 3 0 A , while the donor atoms at the present level of refinement appear to be at 1 92 A from the metal atom

The most interesting difference between *a* and *b* is that in $[Cu(NHCONHCONH)_2]^{=}$ the metal-peptide bonding is via the peptide *nitrogen* atoms, while in $[Cu(NH_2CONHCONH_2)_2]^{++}$ at least two, probably four, of the donor atoms are peptide oxygen atoms At every refinement stage we have recalculated all structure-factors for models having as the ligand atoms respectively four oxygen atoms, two oxygen and two nitrogen atoms, and four nitrogen atoms The agreement between the calculated and observed structure-factors for the first of these models has been consistently and significantly better than for the third, and consistently and slightly better than for the second

At the present stage of refinement of *b* a more detailed description of the ligand is impossible It is quite clear, however, that the complex is bent similarly to *a*, and that the plane of each biuret molecule makes an even larger angle (of about 23°) with the plane containing the copper and donor atoms

By contrast with *a*, the structure of *b* is held together mainly by the electrostatic forces between the complex cations and the chloride anions The only certain hydrogen-bonded contact is that between the secondary nitrogen atom N_2 and a chloride ion which lies at 3 2 A , almost exactly along the line which bisects the angle C—NH—C The complexes lie perpendicular to (001), and a projection of the structure along the *z*-axis would show the compact arrangement of complexes and Cl^- ions in this plane

It has been pointed out by Rabin[16] that, unless a peptide hydrogen atom is lost by dissociation, co-ordination at a peptide nitrogen atom causes the loss of the resonance energy of an amide group Under neutral or acid conditions, co-ordination at the peptide oxygen atom is therefore expected At first sight, this view gains strong support from the structure of *b*, which is precipitated from a neutral alcoholic solution We have not, however, succeeded in showing that the ion $[Cu(NH_2CONHCONH_2)_2]^{++}$ indeed exists in other than the solid state A neutral aqueous mixture of cupric sulphate and excess biuret has an absorption curve between 200 and 1,000 mμ which is indistinguishable from that of the hexaquo-copper(II) ion, and the absorption curve of an alcoholic solution of cupric chloride between 230 and 1,000 mμ is unaffected by the addition of alcoholic biuret solution until precipitation occurs

On the other hand we find, in agreement with Kober and Haw[17], that the violet complex *a* in aqueous solution has an absorption maximum at $\lambda_{max} = 505$ mμ with $\varepsilon_{max} = 43$ The structure analysis thus provides evidence that absorption at this wave-length is indeed characteristic of copper(II) co-ordinated by four peptide nitrogen atoms[8a,17], it being assumed that the complex *a* has the same structure in solution as in the solid (with the probable addition of two water molecules in the octahedral positions)

Finally, our results for the first time confirm a structure which was suggested for the violet copper–biuret complex by Tschugaeff in 1907 [4] They also support the view[1,13,15,16] that in alkaline solution the ionization of peptide hydrogen atoms is responsible for the additional dissociation constants found for the copper complexes of some peptide ligands, and that metal-peptide binding then occurs via peptide nitrogen atoms

Detailed descriptions of the structures and particulars of the methods of refinement are being published elsewhere Concurrently with the further refinement of *b* we are investigating the crystal structures of the cupric complexes of tri- and tetra-glycine with the intention of initiating a systematic attack on the structural questions involved in metal-peptide systems via suitable model compounds

Parts of this work were carried out during the tenures of a George Ellery Hale fellowship at the California Institute of Technology (H C F), and of an Australian Atomic Energy Commission studentship (J C T) Our first crystal specimens were given to us by Dr B M Gatehouse and Dr R J Irving (University of New South Wales) Helpful discussions with them and with Drs A McL Mathieson, B R Rabin, T M Dunn and R W Green are gratefully acknowledged

[1] Rabin, B R , "Metals and Enzyme Activity", 21, edit by Crook, E M (Cambridge University Press, 1958)

[2] Klotz, I M , and Loh Ming, W -C , *J Amer Chem Soc* , **76**, 805 (1954)

[3] Bello, J , and Vinograd, J R , *Nature*, **181**, 273 (1958)

[4] Tschugaeff, L A , *Ber* , **40**, 1973 (1907)

[5] Kober, P A , and Suguira, K , *J Amer Chem Soc* , **48**, 383 (1912)

[6] Jesserer, H , and Lieben, F , *Biochem Z* , **297**, 369 (1938)

[7] Klotz, I M , and Fiess, H D , *J Phys Coll Chem* , **55**, 101 (1951)

[8] (*a*) Plekhan, M I , *Zhur Obshchei Khim* , **22**, 1633 (1952) (*b*) Plekhan, M I , *ibid* , **25**, 603 (1955)

[9] Stosick, A J , *J Amer Chem Soc* , **67**, 365 (1945)

[10] Mathieson, A McL , and Welsh, H K , *Acta Cryst* , **5**, 599 (1952)

[11] Low, B , unpublished work quoted by Sweeney, D M , *et al* , *J Amer Chem Soc* , **77** 5508 (1955)

[12] Hughes, E W , Yakel, H L , and Freeman, H C , *Acta Cryst* (in the press)

[13] Dobbie, H , and Kermack, W O , *Biochem J* , **59**, 246, 257 (1955)

[14] Manyak, A R , Murphy, C B , and Martell, A E , *Arch Biochem* , **59**, 373 (1955)

[15] Datta, S P , and Rabin, B R , *Trans Faraday Soc* , **52**, 1123 (1956), *Biochim Biophys Acta*, **19**, 572 (1956)

[16] Rabin, B R , *Trans Farad Soc* , **52**, 1134 (1956)

[17] Kober, P A , and Haw, A B , *J Amer Chem Soc* , **38**, 457 (1916)

COLOUR-IMAGE SYNTHESIS WITH TWO UNORTHODOX PRIMARIES

By ARTHUR KARP

Engineering Laboratory, University of Cambridge

DR E H LAND, in his recent articles[1,2] and interesting lecture to the Royal Photographic Society last year, has revived interest in the art of synthesizing coloured images with only two primaries The technique is to superpose on a screen the images of two black-and-white slides contained in two projectors having individual coloured light sources The slides for the two projectors, here designated L and S, are always prepared by photographing a scene through red and green filters so that the transparent areas of each slide correspond to light reflected from the scene in the spectral intervals red-to-yellow, and yellow-to-cyan (blue-green) respectively The choice of hues for projection, or for the dyes or inks to be printed on film or paper, however, is open The standard combination, as used in 'Sovcolor', the original 'Warnercolor' and their numerous predecessors[3], is red-orange and blue-green Fox and Hickey, more than fifty years ago, and the Raycol Company, in 1929, employed red and white[3]

By studying these and very many other pairs of projecting primaries in careful experiments, Land has been able not only to create some effective colour pictures, but also to report some new and accurate measurements For example, a surprising gamut of hues, including red, white and blue, may be seen when the S illuminant is greenish-yellow (dominant wavelength $\lambda_S = 579$ mμ) and the L illuminant is orangish-yellow ($\lambda_L = 599$ mμ) With regard to other primary colours, the number of different hues that may or may not be visible in the final result is a function of the primaries To summarize his findings, Land has designated, on a chart having λ_S and λ_L as co-ordinates (ref 2, p 89), hereinafter referred to as Land's colour map, domains indicating the unobtainable final subjective hues To summarize his investigations of how each hue is produced in an image, Land constructed another chart, called the dimensionless co-ordinate system (ref 2, 89), where the names of all the hues are attached to points the co-ordinates of which are the relative L and S illuminations of a spot in a synthesized picture where the particular colour was seen Relative L illumination is defined as the actual intensity of L light at the spot divided by the maximum intensity of L light anywhere in the picture

Many of the above facts have been verified by experiments at the Cambridge University Engineering Laboratory For example, the red-and-white primary combination does allow bluish and greenish hues to appear on the screen, or in a Kodachrome photograph of it, although detailed examination of each image point in isolation reveals nothing but mixtures of red, white and black, even in regions which take on bluish or greenish hues when the isolation is incomplete The term 'in isolation' denotes that an image point is examined by a means which excludes the remainder of the image, including details, such as a highlight, of the object of which the point is a part It also denotes that the eye has not been exposed to any coloured fields immediately prior to the observation

Land has also reported[1 2] that nothing but shades and tints of red can be seen when the S and L slides are wedge filters, giving a gradual change from black to white, oriented as in Fig 1*a*, so that the gradations run from top to bottom in one projector and from left to right in the other We modified this experiment by using stepped wedges overlaid by either a black or a white network to form detached squares against a background (Fig 1*b* and *c*) The results in *b* were monochromatic as in *a* , but with the white network *c* bluish-green hues dramatically appeared in the positions indicated Points of the network, or background, were pink when viewed in isolation through a small-apertured telescope, but in context appeared quite white The bottom right-hand square was white in isolation, but cyan—the complementary of red—in context Gelatine filters of various colours were then inserted in either or both of the projectors Without a white background, only mixtures of the original primaries were seen Against the white background, colours that were easily recognized as mixtures of two new primaries became visible Each new, or revised primary, was in turn recognized as one of the original primaries mixed with the

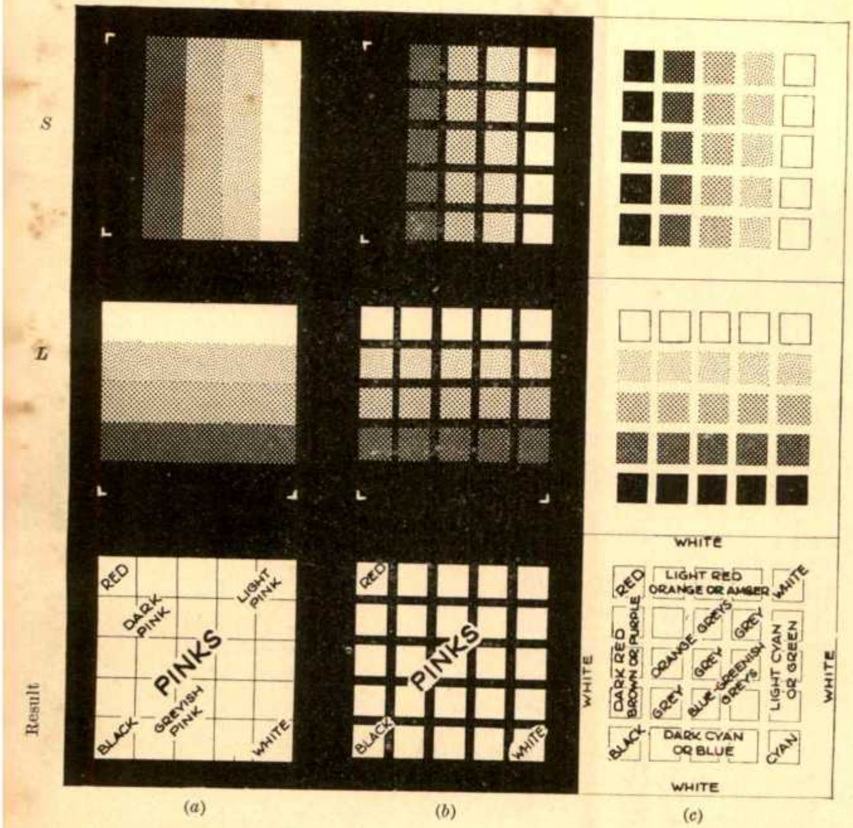

Fig. 1. Method of projecting array of squares with slides of horizontal and vertical step wedges. *a*, No background; *b*, black background; *c*, white background. Top row: slides for *S* projector; second row: slides for *L* projector; bottom row: subjective result with red *L* and white *S* primary illuminants

complementary of the other. This prevalence of complementary-hue generation strongly suggests that the physiological and/or psychological effects that occur in unorthodox two-colour synthesis are probably related to those which occur in simultaneous or successive contrast, as in the striking experiment wherein a red light instantly appears cyan—or a green light, magenta—when viewed through a hole in a rotating disk the surface of which is half white and half black.

The remarkable contribution of the subjectively white background suggested other experiments with white cues. Whatever the primary hues, it was found that a synthesizable composition had to include areas which were psychologically more acceptable when neutral, such as a border or background which could be white or grey or even a rather dark grey. Excellent, though subtle, white cues are the highlights on glossy objects. Though very small they are hard to avoid in natural scenes other than landscapes, and, regardless of the colour of the underlying object, may provide the most intense white in the entire composition, as artists and television camera-men will confirm. The tolerance on mis-registration of the two constituent images was found to be related to the loss of identity of the tiny highlights in the scene.

Only occasionally did the masking-off of all white cues fail to remove completely the impressions of cyan in a red-and-white synthesis. Even then, the residual impression usually faded away after several seconds. If it did persist, it was when red areas were nearby and simultaneous contrast was occurring. In this case the residual cyan would vanish after a pale blue gelatine filter was passed in and out of the beam of the *S* projector—a procedure which had no effect on a picture containing white cues.

In each screen image, whether a still life or abstract composition, much was learned by watching (1) the *warmest spot*, (2) *coolest spot* and (3) *white cue*, as the primary colour filters were changed and/or intensities of illumination varied. These three regions receive maximum light from (1) the *L*-projector alone, (2) the *S*-projector alone, and (3) both projectors, respectively, and may thus incidentally be associated with the datum levels of Land's dimensionless co-ordinate system. As the relative intensities of the primaries were varied, the subjective colour of the white cue appeared as a *desaturated* version of their mixture, and for many primary pairs, a point could be reached when the white cue object or region appeared as a "very good white". In brightness and hue, the apparent colour of the warmest spot was recognized as that of the *L* projector's light mixed classically with the complementary of the *S* projector's light, the intensity of the second component being small or large accordingly as the *S* projector's light was relatively dim or bright. For the coolest spot, read the foregoing sentence with *S* and *L* interchanged.

These results can be described more quantitatively with the help of the classical C.I.E. chromaticity chart[4]. As an example, Fig. 2*a* has been drawn for one of the remarkable pairs of primaries used by Land[2]—greenish-yellow *S* (579 mμ) and orangish-yellow *L* (599 mμ). Intensity is measured perpendicular to the page, so that the chart represents lines and planes in colour space projected into the plane having medium neutral grey at O. All the physical chromaticities of the projected scene lie in the line *LS*. As light intensities are varied, the physical chromaticity of a white-cue spot (*W*) obviously moves along *LS*, but its subjective chromaticity is seen to depart from *LS* and follow the dashed curve *LW'S*. The separation O*W'* at the closest approach to O is exaggerated in the figure, for it is usually small if *W* originally falls in a yellow or other light or desaturated region of the chart. The reason for the shift of *W* to *W'* is probably psychological, and may be accompanied by a physiological process giving involuntary and rapid adjustment of the sensitivities of one or more of the retinal or cortical colour sensors in the direction of restoring the neutrality of hue of the parts of the image which the observer, perhaps subconsciously, expects or prefers to be neutral. (In projecting conventional colour transparencies, one may also observe the tendency to retain the whites and greys in the original picture when a flood of coloured light is superposed.) Possibly because of retinal or cortical

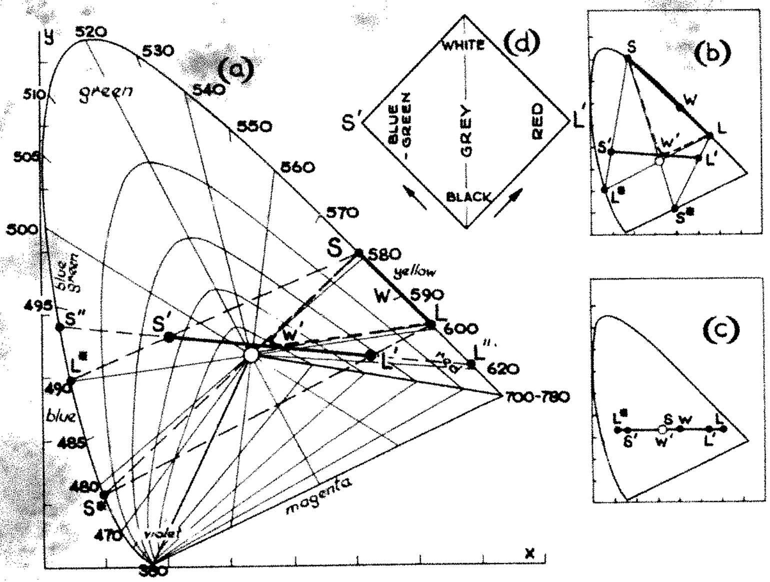

Fig. 2. Transformation of physical locus of chromaticities (SL) to mental locus of chromaticities ($S'L'$) via the white-cue effect. *a*, Primaries 579 and 599 mμ; *b*, primaries 535 and 589 mμ; *c*, primaries white and orangish-red; *d*, final colour plane

interconnexions, the observer's controls seem to act as well over the remainder of whatever scene is sharing a common frame with the white cues, and the effect is one of partial subtraction of the original primaries over the area within this frame.

The subjective chromaticity of the warmest spot lies at L' between L and the complementary of S, that is, S^*. The distance LL' increases as the relative intensity of S is increased. Similarly, the coolest spot's chromaticity S' lies on SL^*, with $SS'/S'L^*$ depending on the ratio of the intensities of L to S, which is set when adjusting for the best rendering of white and grey. The subtractions have produced revised primaries, S' and L', and a revised locus, $S'W'L'$—virtually $S'OL'$—for all the subjective hues of the scene which, at the price of desaturation, is seen to embrace a much larger range of hues than SL (ref. 2, p. 86). Replacement of the monochromatic primaries with gelatine-filtered light of the same dominant wave-lengths shifts S, L, S^* and L^* to points slightly inside the spectrum locus, with little effect on the result. Similar diagrams (Fig. 2*b*) are readily constructed for any other primary combination including those in which one member of the pair is white (Fig. 2*c*). The colours in $S'L'$ are all desaturated to roughly the same extent, so that one usually obtains a pleasingly restrained and dignified[3] artistic effect like that of a water-colour painting. Primaries such as S'' and L'', for example, lead to similar final hues; but the effect can be harsh or gaudy.

When $S'L'$ is roughly parallel to the x axis, Land's co-ordinate system can be related to the plane through $S'L'$ normal to the page (Fig. 2*d*). For other orientations of $S'L'$, the hues lying far from $S'L'$ correspond to those stated to be unobtainable in Land's colour map. For example, when $S'L'$ runs from blue to yellow, it gives wide berth to red, green and magenta. When the primaries are blue L (440–510 mμ) and violet S (400–435 mμ), the construction makes S' and L' fall in the magenta and green regions, respectively. Not only are all other hues now unobtainable, but the revised cool primary S' is now warmer (redder) in aspect than L'. (See the region marked "short wave reversal" in Land's colour map.)

A final problem concerns the fact that some of the colours, such as yellow, purple, deep blue, etc., which are sometimes seen in synthetic still life and other compositions, do not lie within $S'L'$ (Fig. 2*d*) which, to use an analogy, has only "four paints on its pallette"—red, cyan, black and white. Numerous experiments with many observers suggest that a psychological factor, probably related to the effect of the picture on the observer's emotions, determines whether the subjective colours will be limited to those of $S'L'$ or whether hues from closely adjoining regions in the C.I.E. chart may be co-opted by the imagination. For example, with synthesized pictures of most geometrical patterns, or of an uninteresting collection of variously coloured but otherwise identical polished plastic spheres, no colours outside the limited range of $S'L'$ were noted in the projected image by indifferent observers to whom no suggestions were given. However, if suggestions were given, or if the scene possessed the least trace of human interest, $L'S'$ colours such as cyan, dark desaturated cyan, light pink and dark grey might convincingly appear to some observers, respectively, as a green, blue, yellow and violet of the same lightness, and a low-intensity red could sometimes appear either as chocolate, claret, mahogany, or purple. When viewing the array-of-squares projections (Fig. 1*c* bottom) some observers reported seeing spectral sequences in the rows or columns and named individual squares as amber, orange, purple, indigo, etc. Unanimous agreement among normal observers, however, could only be approached when the objects actually were of an $L'S'$ colour, or when they had an established identity, such as daffodils, ivy leaves, a croquet set, hair, sky, a Chinese teacup, etc.

To conclude, we believe that, in conjunction with the phenomenon of overlapping in the subjective distinctions between colours of equal lightness and adjacent hue, the white-cue effect—which, in restoring the sensations of white and grey to a framed image, causes the original primaries of that frame each to be modified by the addition of the complementary of the other—adequately explains the various phenomena associated with the unorthodox two-colour synthesis of images of natural objects.

I am indebted to Prof. W. R. Hawthorne for his generous sponsorship and encouragement of the project and many helpful discussions and suggestions. The valuable comments of Dr. W. A. H. Rushton and Dr. E. N. Willmer are gratefully acknowledged, as is the technical assistance of Messrs. E. R. Mudd, E. D. Nisbet, L. R. Peters and the staff of the Engineering Laboratory Workshop under A. A. Barker. Thanks are also extended to the scores of observers whose comments are a necessary part of any subjective study.

[1] Land, E. H., *Proc. U.S. Nat. Acad. Sci.*, **45**, 1, 115; 4, 636 (1959).
[2] Land, E. H., *Sci. Amer.*, 84 (May 1959).
[3] Cornwell-Clyne, A., "Colour Cinematography", third ed. (Chapman and Hall, Ltd., 1951).
[4] de Groot, W., and Kruithof, A. A., *Philips Tech. Rev.*, **12**, 5, 137 (1950).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 26

Royal Geographical Society (at 1 Kensington Gore, London, S W 7), at 5 p m —Prof Michael J Wise "Great Cities of Japan"

University College (in the Physiology Theatre, Gower Street, London, W C 1), at 5 30 p m —Prof A Fleckenstein (University of Freiburg) "The Metabolism of Labile Phosphate Compounds in Living Muscle, Studied with Radioactive Phosphorus and Paper Chromatography" (First of two lectures on "Isotopic Studies of Phosphorus Metabolism in Skeletal and Heart Muscle" Further lecture on October 28)*

University of London (at Birkbeck College, Malet Street, London, W C 1), at 6 p m —Prof E G Boring (Harvard University) "Current Trends in American Psychology" (Last of three lectures on "The Pattern of Modern Psychology")*

Tuesday, October 27

University College (in the Anatomy Theatre, Gower Street, London, W C 1), at 1 15 p m —Dr Elizabeth M Deuchar "How Embryos Develop—Grafting Experiments and the Organiser Concept" *

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W C 2), at 5 30 p m —Discussion on "Future Trends in Memory Stores for High-Speed Digital Computers", opened by Mr W Renwick

Illuminating Engineering Society (at the Federation of British Industries, Tothill Street, London, S W 1), at 6 p m —Mr A N Irens "Light and Productivity" (Golden Jubilee Lecture)

Institution of Mechanical Engineers, Automobile Division (at 1 Birdcage Walk, Westminster, London, S W 1), at 6 p m —Mr Leonard Raymond "Engineering Challenges to American Automotive and Petroleum Research"

Society of Instrument Technology (at Manson House, 26 Portland Place, London, W 1), at 7 p m —Mr J H Bach and Mr G E Fishter "Modern Developments in Optical Instruments"

British Association for the Advancement of Science, in association with Granada TV Network, at the Guildhall, London, E C 2), at 8 30 p m —Sir Eric Ashby Third of the Inaugural Series of the Granada Lectures on the theme of "Communication in the Modern World"

Wednesday, October 28

Institution of Electrical Engineers, Electronics and Communications Section (at Savoy Place, London, W C 2), at 5 30 p m —Mr M J L Pulling "Development of Eurovision" (Chairman's Address)

Institution of Mechanical Engineers, Applied Mechanics Group (at 1 Birdcage Walk, Westminster, London, S W 1), at 6 p m —Prof J L M Morrison, Prof B Crossland and Dr J S C Parry "Strength of Thick Cylinders Subjected to Repeated Internal Pressure"

Society of Chemical Industry, Food Group—Nutrition Panel (at 14 Belgrave Square, London, S W 1), at 6 15 p m —Mr A E Bender and Mr B H Doell "The Nutritionist and the Food Industry"

Thursday, October 29

University College (in the Anatomy Theatre, Gower Street, London, W C 1) at 1 15 p m —Dr G E Fogg "Life on Mars" *

University of London (at the Imperial College of Science and Technology, London, S W 7), at 1 30 p m —Mr S J Gould "Industry and Society 1—The Sociologists Look at Industry" * (First of five lectures Further lectures on November 12, 19, 26 and December 3)

University of London (at the Senate House, London, W C 1), at 5 30 p m —Dr Kenneth M Smith, C B E , F R S "Recent Work on the Electron Microscopy of Viruses" *

Institute of Physics (at 47 Belgrave Square, London, S W 1), at 6 p m —Prof G O Jones "New Uses for Low Temperatures"

Friday, October 30

University of London (at the Institute of Neurology, National Hospital, Queen Square, London, W C 1), at 5 30 p m —Dr Paul C Bucy (Chicago) "Neural Mechanism Responsible for the Control of Motor Activity"

Royal Institution (at 21 Albemarle Street, London, W 1), at 9 p m —Mr F C Bawden, F R S "Plant Viruses What They Are and What They Do"

Saturday, October 31

Society for Forensic Science (in the Lecture Theatre, Portland Building, University of Nottingham), at 10 a m and 2 p m —Inaugural Meeting

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned

Fellow or Senior Fellow in Philosophy within the Department of Social Philosophy, Australian National University, Canberra—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, November 10)

Assistant (with a degree in botany or horticulture or equivalent, and preferably experience in microscopy, and mathematical ability) in the Pomology Section, for work on plant anatomy—The Secretary, East Malling Research Station, near Maidstone, Kent (November 15)

Chair of Metallurgy in the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (South Africa, November 15)

Biochemist (with two or three years research experience in agricultural chemistry, and preferably with M Sc or Ph D qualifications), for duties which include supervision of routine soil and plant analyses and research on the composition and properties of tobacco—The Director, Tobacco Research Board of Rhodesia and Nyasaland, P O Box 1909, Salisbury, Southern Rhodesia (November 16)

Senior Lecturer, Lecturer and a Senior Demonstrator in Physiology at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, November 16)

Lecturers or Assistant Lecturers in Botany, Chemistry, Geography, Mathematics and Zoology at the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (November 20)

Chair of Anatomy tenable in the Newcastle Division of the University—The Registrar, University Office, 46 North Bailey, Durham (November 21)

Lecturer in Civil Engineering at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, November 27)

Lecturer (with qualifications in either pure or applied mathematics) in Mathematics at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (New Zealand, November 30)

Mycologist (with a good honours degree in botany with mycology as a special subject, a knowledge of the more fundamental aspects of animal and human mycoses, and preferably with a knowledge of Latin and other languages) at the Commonwealth Mycological Institute, Kew—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (November 30)

Biochemist (with M Sc or higher university degree), for work in the field of plant nutrition, with special reference to micro-elements and enzyme activity—The Director, Cawthorn Institute, Nelson, New Zealand (December 15)

Chair of Geography in the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (New Zealand, December 15)

Assistant or Associate Professor of Pathology at Queen's University, Kingston, Canada—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Digest of Soviet Technology, No 1 (April 1959) (Express Information on Recent Technological Developments in the Soviet Union and Eastern Europe) Pp 36 Annual subscription rate (12 issues) £6 6s 0d post free (Kirkham, Preston Engineering Information Services, 1959) [287

Dauntsey's School Natural History Society Annual Report, 1957–8, 1958–9 Pp 23 (West Lavington, Devizes Dauntsey's School, 1959) 1*s* 6*d* [287

Committee of Privy Council for Medical Research Report of the Medical Research Council for the year 1957–1958 Pp viii+288 (Cmnd 792) (London H M Stationery Office, 1959) 13*s* net [297

Ministry of Labour and National Service Annual Report of the Chief Inspector of Factories on Industrial Health for the year 1958 Pp iv+61 (Cmnd 811) 3*s* 6*d* net Annual Report of the Chief Inspector of Factories for the year 1958 Pp 95 (Cmnd 810) 5*s* 6*d* net (London H M Stationery Office, 1959) [307

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Educational Productions, Ltd Filmstrip No CX 6208 *Resident British Birds* 33 frames 27*s* 6*d* Notes for use with Filmstrip No CX 6208 Pp 19 (East Ardsley, Wakefield Educational Productions, Ltd , 1959) [68

The United Kingdom Dairy Industry Edited by Prof E L Crossley (Prepared under the auspices of the XV International Dairy Congress on behalf of the United Kingdom Dairy Association) Pp viii+142+16 plates (London United Kingdom Dairy Association, 1959) [108

Other Countries

Annals of the South African Museum, Vol 45, Part 1 Contributions to the knowledge of South African Marine Mollusca Part 2 Gastropoda—Prosobranchiata Rhachiglossa By K H Barnard Hydrozoa from Ships' Hulls and Experimental Plates in Cape Town Docks By N A H Millard Pp 257 (Cape Town South African Museum, 1959) 46*s* [277

South African Council for Scientific and Industrial Research National Building Research Institute Corrosion of Concrete Sewers Pp xiv+236 (Pretoria South African Council for Scientific and Industrial Research, 1959) [277

Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture Comptes Rendus de Recherches No 21 (Juin, 1959) Werkzaamheden van het Comité voor de Studie van de Ziekten en de Voeding van het Rundvee Pp 91 140 francs No 22 (Juin, 1959) Travaux du Centre Belge d'Études et de Recherches en Fonderie [Pp 230 240 francs (Bruxelles Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture, 1959) [277

Académie Royale de Belgiqe Classe des Sciences Tome 31, Fascicule 1 Étude Phytosociologique de la Fagne Wallonne et de la Fagne de Clefay—(Structure et Évolution des Associations Végétables à Sphaignes dans les Hautes-Fagnes de Belgique · Par M Streel Pp ii+109 160 francs Tome 31, Fascicule 3 *Le Granite et les Déformations Mineures des Roches (Schistosité, Microplissement, etc)* Par P Fourmarier Pp 101 100 francs Tome 31, Fascicule 4 'Une Classe de Modèles Euclidiens pour Métriques Variationnelles Par Marcel Coz Pp 42 40 francs Tome 31, Fascicule 5 Sur les Congruences Pseudosphériques Par Prof F Backes Pp 31 40 francs (Bruxelles Académie Royale de Belgique, 1959) [277

Food and Agriculture Organization of the United Nations FAO Nutrition Meetings Report Series No 23 Report of the Regional Seminar on School Feeding in South America, Bogota (Colombia), 27 October—8 November 1958 Pp iii+60 (Rome Food and Agriculture Organization of the United Nations, 1959) 3*s* 6*d* , 0 75 dollars [287

The Canada Council Second *Annual Report to March 31, 1959* Pp vi+112 (Ottawa The Canada Council, 1959) [287

New Zealand Department of Scientific and Industrial Research Geophysics *Division* Seismological Observatory Bulletin S–106 Earthquakes in New Zealand during the year 1954 By R C Hayes Pp 5+1 map (Wellington Government Printer, 1959) [297

New Zealand Forest Service Forest Research Institute Forest Research Notes, No 12 Tests of some Instruments for Measuring Tree Height By W G Warren Pp 18 Forestry Research Notes, No 16 Notes on the Physical Properties of Ponderosa Pine, Monticola Pine, Western Red Cedar, and Lawson Cypress Grown in New Zealand By J M Harris and S Kripas Pp 24 (Wellington Government Printer, 1958) [297

Government of India Meteorological Department *Reports on the* Administration of the Meteorological Department of the Government of India Year 1950–51 Pp 56+8 plates Year 1952–53 Pp 62+5 plates Year 1954–55 Pp 81+8 plates Year 1955–56 Pp 91+6 plates Year 1956–57 Pp 72+10 plates (Simla Government of India Press, 1955 and 1958) [297

Forest Research in India, 1951–52 Part 2 Reports from Burma and Indian States Pp ii+194 Rs. 4 25 , 6*s* 9*d* Forest Research in India, 1955–56 Part 1 The Forest Research Institute Pp v+167 Rs 4 , 6*s* 6*d* (Delhi Manager of Publications, 1957) [307

South Australia Institute of Medical and Veterinary Science Twentieth Annual Report of the Council, July 1957–June 1958 Pp 91 (Adelaide Institute of Medical and Veterinary Science, 1959) [307

Federation of Nigeria Annual Report on the Department of Agricultural Research for the year 1957–58 Pp 43 (Lagos Federal Government Printer, 1959) [307

B A N Z Antarctic Research Expeditions, 1929–1931 Reports—Series B (Zoology and Botany) Vol 6, Part 10 Radiolaria in *Antarctic Sediments* By William R Riedel Pp 217–256 (4 plates) 16*s* Vol 6, Part 11 Scleractinian Corals By John W Wells Pp 257–275 (2 plates) 12*s* Vol 6, Part 12 Turbellaria By Dr Libbie H Hyman Pp 277–290 8*s* Vol 6, Part 13 Free-Living Nematodes Section 2 Additional Enoploidea from Antarctic Stations By Patricia M Mawson Pp 291–306 4*s* 6*d* Vol 6, Part 14 Free-Living Nematodes Section 3 Enoploidea from Subantarctic Stations By Patricia M Mawson Pp 307–358 17*s* (Adelaide B A N Z A R Expedition Committee, 1958 Issued through the Barr Smith Library, University of Adelaide) [307

American Academy of *Arts and Sciences, Boston* Francis Amory Prize Recipients Amory Prize Lectures 1947 Medical Significance of the Amory Prize Researches By Charles Huggins 1954 Man, Beast, and *Field* By Terence Millin From the Will of Francis Amory Pp 32 Records of the Academy, 1958–1959 Pp 122 The American Academy of Arts and Sciences Pp 19 (Boston American Academy of Arts and Sciences, 1958 and 1959) [317

Studia Universitatis Lovanium Faculté des Sciences No 9 Paléolithique Ancien à Léopoldville Par Hendrik Van Moorsel Pp 24 (Leopoldville Editions de l'Universite, 1959) 35 francs [58

United States Atomic Energy Commission Report ORINS-25 The Acute Radiation Syndrome—a Medical Report on the Y-12 Accident, June 16, 1958 Compiled by Marshall Brucer Pp viii+188 (Washington, D C *Office of Technical Services, Department of* Commerce, 1959) 1 dollar [58

University of Sydney School of Agriculture Report No 4 The *Commercial* Use of Nitrogenous Fertilizers and Autumn Sown Oats for the Production of Winter Dairy Forage By F C Crofts Pp 41 (Sydney The University, 1959) [58

University of Kansas Museum of Natural History Miscellaneous Publication No 17 Birds of the Ungava Peninsula By Francis Harper Pp 1–171 (Lawrence, Kansas The University, 1958) [58

United States Department of the Interior Geological Survey Bulletin 1019–N Selected Bibliography of Andalusite, Kyanite, Sillimanite, Dumortierite, Topaz, and Prophyllite in the United States By Agnes B Gramebaur Pp iii+973–1046+plate 6 45 cents Bulletin 1046–K Results of Geologic Exploration by Core Drilling, 1953, Land-Pebble Phosphate District, Florida By James B Cathcart and Lawrence J McGreevy Pp iv+221–298+plates 16–34 Bulletin 1072–E Areal Geology of the Placerville Quadrangle, San Miguel County, Colorado By A L Bush, C S Bromfield and C T Pierson Pp iv+299–384+plates 4–8 Bulletin 1074–E Uranium in Phillips Mine—Camp Smith Area, Putnam and Westchester Counties, New York By Harry Klmeic, John H Eric, James R McNitt, and Frank A McKeown Pp iv+165–199+plates 11–13 Bulletin 1081–A Graphic-Locator Method in Geologic Mapping By David J Varnes, Tommy L Finnell and Edwin V Post Pp iii+1–10+plate 1 ,15 cents Bulletin 1086–E Index to Geophysical Abstracts 172–175, 1958 By Dorothy B Vitaliano and others Pp iii+1–128 35 cents (Washington, D C Government Printing Office, 1959) [58

United States Department of the Interior Geological Survey Water-Supply Paper 1320–C *Floods of April–June 1953 in Louisiana* and Adjacent States Prepared under the direction of J V B Wells Pp ix+155–320+plates 5–7 Water-Supply Paper 1467 Ground-Water Appraisal of Santa Ynes River Basin, Santa Barbara County, California, 1945–52 By H D Wilson, Jr Pp vi+119+plates 1–8 Water-Supply Paper 1468 Geology and Ground-Water Resources of Clay County, Nebraska By C F Keech and V H Dreeszen Pp vi+157+plates 1–4 1 50 dollars Water-Supply Paper 1470 Geology and Ground-Water Features of the Eureka Area, Humboldt County, California By R E Evenson Pp iv+80+plates 1 and 2 Water-Supply Paper 1476 Investigations of Sediment Transportation, Middle Loup River at Dunning, Nebraska By D W Hubbell and D Q Matejka Pp vi+123+plates 1–13 Water-Supply Paper 1496–A A Survey of *Analytical Methods for the Determination of* Strontium in Natural Water By C Albert Horr Pp iii+1–18 15 cents Water-Supply Paper 1514 Surface Water Supply of the United States 1957 Part 10 *The Great Basin* Prepared under the direction of J V B Wells Pp viii+233 1 dollar Water-Supply Paper 1516 Surface Water Supply of the United States 1957 Part 12 Pacific Slope Basins in Washington and Upper Columbia River Basin Prepared under the direction of J V B Wells Pp ix+358 (Washington, D C Government Printing Office, 1959) [58

United States Department of the Interior Geological Survey Professional Paper 260–W Lower Eocene Phosphatized *Globigerina* Ooze from Sylvania Guyot By Edwin L Hamilton and Robert W Rex Pp iii+785–798+plates 250–254 Professional Paper 280–K Geology of Saipan, Mariana Islands Part 4 Submarine Topography and Shoal-Water Ecology By Preston E Cloud, Jr Pp vi+361–445+plates 120–139 Professional Paper 307 Geology of the Pierre Area, South Dakota By Dwight R Crandell Pp iv+1–183+plates 1–3 Professional Paper 319 Geology and Ore Deposits of the Chicago Creek Area, Clear Creek County, Colorado By J E Harrison and J D Wells Pp v+92+plates 1–13 Professional Paper 321 Cenozoic Echinoids of Eastern United States By C Wythe Cooke Pp iii+106+plates 1–43 (Washington, D C Government Printing Office, 1959) [58

Year-Book of the Institute of Nutrition, Budapest, for 1958 Pp xiv+102 (Budapest Institute of Nutrition, 1959) [

Population Reference Bureau, Inc , Washington Population Bulletin, Vol 15, No 4 (July, 1959) U S S R Census—a Power Myth Exposed Pp 61–80 (Washington, D C Population Reference Bureau, Inc , 1959) [68

Bulletin of the American Museum of Natural History Vol 118, Article 2 The Species of *Nimravus* (Carnivora, Felidae) By Loren Toohey Pp 71–112+plates 9–22 (New York American Museum of *Natural* History, 1959) 1 50 dollars [68

Transactions of the American Philosophical Society New Series Vol 49, Part 4 The Medieval Theories of the Just Price—Romanists, Canonists, and Theologians in the Twelfth and Thirteenth Centuries By John W Baldwin Pp 92 (Philadelphia American Philosophical Society, 1959) 2 dollars [68

Geological Survey of British Guiana Bulletin No 27 The Gold Deposits of the Cuyuni River By R T Cannon Pp 69 (Georgetown Geological Survey, 1958) 1 dollar [78

Publications of Field Museum of Natural History, Chicago Zoological Series Vol 25, Part 4 A Bibliography of Birds, with special reference to Anatomy, Behavior, Biochemistry, Embryology, Pathology, Physiology, Genetics, Ecology, Aviculture, Economic Ornithology, Poultry *Culture, Evolution, and related subjects* By Prof Reuben M Strong Pp i+186 (Publication 870) (Chicago Field Museum of Natural History, 1959) 2 75 dollars [78

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO , LTD ,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number Whitehall 8831 Telegrams Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

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Telephone Number Holborn 4743

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THE STUDY OF MAN

DESPITE comments during recent years that the British Association for the Advancement of Science appeared to have lost both its bearings and its impetus, it has been generally acknowledged that the presidential address has always been much more than a rallying call at an annual meeting; it has increasingly come to be recognized as a statement by a leading man of science to the nation. In these addresses, each president has considered a theme which often has reflected outstanding interests of men of science at that particular time. In a discipline which daily grows more complex and bewildering, Sir Edward Appleton at Liverpool pleaded with men of science to make themselves intelligible to the layman; without an informed populace he showed that science could not flourish. At the Dublin meeting, Prof. P. M. S. Blackett was concerned with the need for applying science and technology on a world-wide front to solve world-wide problems of poverty and distribution. With his own travels as background, Prince Philip at Edinburgh discussed international aspects of science and how they could contribute to better understanding between peoples everywhere. Now, in a world where powerful blocs have realized that material strength alone is not enough, this year's president, Sir James Gray, invites men of science everywhere to pay full regard to moral principles and the social repercussions of their discoveries (see p. 35 of this issue).

The address is noteworthy for a number of features. First, because Sir James Gray has looked at science as a whole and has supported his arguments by evidence drawn from a number of the sections which comprise the British Association; he himself has acted as a link between them. Secondly, because he has used the life-science of biology to show its unifying influence in the overall study of man and, thirdly, because he has used his own wide background to examine defects in the educational system before making suggestions both for spreading and applying knowledge of science and technology throughout the world and for making it part of the general philosophy of man. Like others in this famous series, his address will be long remembered as a contribution to man's general evolutionary progress.

Two of Sir James's general topics will command widespread support. The ever-present need to consider the beneficial effects of science on international relationships is made very difficult in a world where science is primarily seen as a manufacturer and distributor of hydrogen bombs; Sir James is emphatic that the primary objective of men of science should be to illuminate the beauty of science, its inflexible pursuit of truth, its challenge to courage and tenacity and its power to inspire.

The place of science in a general philosophy of life is equally well put. Like music, science knows no barriers, and the combined efforts of scientists throughout the world are necessary if man is to continue in his efforts to unravel the secrets of Nature. Where there are political restraints, where knowledge is bounded materially and mentally by local and national barriers, the man of science can provide a bridge which should encompass the Earth. Missiles should be guided, not to destroy mankind, but to bring fresh delight in making clearer the mysteries of the heavens.

To make wise and humane use of science, as Sir James rightly points out, something more than statistics or the precise laws of physics and chemistry will be required. The challenge is to the less well-defined biological sciences and to the ill-defined social sciences arising from them. These sciences must be vigorously pursued not only to discover more of man himself, but also of his relationships with his fellows everywhere; they must also be more widely taught so that more and more people have better opportunities for understanding themselves and other people. Sir James is right to emphasize that it is in the biological and social sciences that the answer may be found as to whether or not science has real cultural significance. In his address, the new president of the British Association also shows the practical nature of the biological sciences, and that man still has much to learn from his evolutionary predecessors. Students of aeronautics, navigation and communications would hasten further discoveries if they paid more attention to biology. It could be added that many students of the humanities and of the physical sciences could considerably reduce the cost of the National Health Service if they would but study some of the general principles of biology; in so doing they would improve their health and, presumably, their happiness.

In the field of demography, Sir James uses his own arguments to give full support to conclusions put forward by Prof. Blackett in Dublin. With evidence drawn from the study of natural evolution, he clearly and courageously puts his choice before all civilized beings. Accepting the discipline of voluntary limitation of families, man can direct the course of his own evolution without the evil consequences of over-population; if he "behaves like an animal and allows his population to increase while each nation steadily increases the complexity and range of its environment, Nature will take her course and the law of the jungle will prevail". Churches throughout the world should examine their doctrines to see whether they are spiritually justified in bringing misery and destitution to so many people, and whether they are indeed helping man to achieve the highest moral and spiritual development of which he is capable. Men, Sir James says, really ought to be able to do something better than ants.

In another comparison of man and animals, Sir James again shows the practical advantages which deeper study of the biological sciences could bring. Study of the learning process has revealed five basic principles, all of which could be applied to the training of human beings. These principles could be made much more use of by teachers everywhere and could revolutionize existing training methods in industry, adoption of these principles could so influence productivity that the well-being of many under-privileged peoples could be improved The all-too-prevalent rule-of-thumb methods used to control industry, which were described by Sir Alexander Fleck at Glasgow last year, would quickly disappear if Sir James Gray's biological principles were widely adopted in education and training

From his own education and experience, Sir James treads a well-worn path in pleading for a wider outlook in the teaching of science Where the majority of children are still leaving school without any real acquaintance with science, it is right that the president of the British Association should support his predecessors in advocating the teaching of science to more children more often Adults, too, should not be neglected, and much responsibility rests on existing and projected area organizations of the British Association In those areas where they have already gone to work they have taken on their tasks with enthusiasm and energy They can do much to support their president and to make the British Association once more regarded not only as an organization which holds an annual meeting, but also as the spearhead for spreading interest in science throughout Great Britain In so doing they can also help the British people to understand more deeply the meaning of democracy and to accept the responsibilities it brings

THE IMPORTANCE OF BEING HUMAN

The Importance of Being Human
Some Aspects of the Christian Doctrine of Man
By E L Mascall Pp vii+118 (London Oxford University Press, 1959) 10*s* 6*d*

A BOOK on the Christian doctrine of man in the light of modern science can at least be said to have a subject of vital concern to all who care for religion Though Dr Mascall has not written a comprehensive treatise, he has dealt with some of the fundamental questions, and it need not be added that he is well equipped both by his knowledge of science and his theological learning for the task

There are two kinds of book on this topic, one that is prepared to modify or 're-interpret' the Christian dogmas and the other that defends them with no accommodation to modern thought Dr Mascall's book belongs to the latter class Though, of course, he is ready to restate the doctrine of the Church to make it more intelligible, he will not contemplate any radical revision He writes as one who accepts an Aristotelian metaphysic, in the main according to the theistic version of St Thomas, and regards the tradition of the Christian Church as revealed truth It is to be hoped, however, that these presuppositions will not deter readers from attending to what he has to say, for he touches on problems that need to be faced The modern man's difficulty about understanding his nature and status in the universe, Dr Mascall thinks, is largely due to the fact that science appears to allow him no "special and assigned status" and no "definite and determined nature" Scientific discourses on the uniqueness of man really leave the ordinary man in the dilemma that he does not have any clear idea of what being human means He was better off in this respect when he could be satisfied with the assurance that man is the "rational animal" Dr Mascall rejects the suggestion that man may be a stage in the evolution of some higher kind of being The Incarnation, he holds, must prohibit any Christian from regarding man as a stepping-stone to some superman "If the Christian religion is true, we have quite solid reasons for holding that, whatever developments man is meant to undergo, man is meant to remain man , for, if God has himself become man in the Incarnation, he has sealed human nature with a certificate of value whose validity cannot be disputed" I think this quotation gives the keynote of the book It leads on to discussions of "Body and Soul", "Individual and Society", "Nature and Supernature", "Man Fallen and Man in Christ", all of which are characterized by shrewd insights and an uncompromising adherence to traditional Christian doctrine A particularly interesting and important point is elaborated in the chapter on "Nature and Supernature", where Dr Mascall develops the conception of "the fundamental openness of man s being to God's activity" as the basis of "the Catholic doctrine of the elevation of man's nature to the level of supernature by grace"

Much in this book will seem to scientific humanists strange and unacceptable, but they may learn something from it and in any event there is æsthetic pleasure in reading a thesis clearly stated and ably argued W R MATTHEWS

T. H. HUXLEY

T H. Huxley
Scientist, Humanist and Educator By Dr Cyril Bibby Pp xxii+330+13 plates (London C A Watts and Co , Ltd , 1959) 25*s* net

TOO many people remember T H Huxley simply as 'Darwin's bull-dog' The occasion of dramatic reproof to an ill-mannered and ignorant bishop is a single incident that obscures a life of energy and devotion in many fields , and Dr Bibby's book, painstaking though it is, does not really succeed in communicating the excitement of the intellectual battlefields over which its hero fought Partly this is due to its arrangement The author has discarded a straightforward biographical treatment in favour of one in which separate sections deal with particular aspects of Huxley's interests The result is to dehumanize the central character, to make him less a vivid and warm personality than a mouthpiece for sentiments that leave an impression of worthiness rather than intensity But the cause of this flatness is not primarily Dr Bibby's fault , it is simply that much of what Huxley thought and said is no longer a daring adventure of ideas His reputation has suffered by his own success He appears less exciting to us than he did to his contemporaries because many of the battles which he fought with such vigour have now been won The biological views which he supported are in modified forms part of the accepted fabric of our thought The aim of an adequate provision of scientific education, or indeed of adequate and universal education of any kind, which he spent himself in promoting is now, if not achieved, at any rate acknowledged as a necessity for a civilized community; and at a deeper level the scientific and rational attitude which was the mainspring of his life and work is nominally at least part of the intellectual climate of our time.

But it would be a very superficial view of Huxley that dismissed him as a thinker from whom we have nothing to learn. Huxley was a man who was very characteristic of his time; it can truly be said that he embodied those qualities of the Victorian Age which we can most envy and most admire. It was an age of principles and of beliefs, and Huxley himself believed passionately in the value of human reason, in the power of education to transform societies, and in the power of science to change not only man's environment but also his habits of thought. He was a Victorian of the same mould as Thomas Arnold and George Eliot. To the causes in which he believed he sacrificed his own scientific achievement, and it is an interesting speculation as one reads this book to ask whether or not Huxley was right to leave undone the original work he might have carried out in the laboratory and instead spend endless hours in committees, on the London School Board or in writing controversial articles. For him education, science and greater social equality were causes to be fought for with incredible industry, with the resources of a superb gift of writing, and with a pervading moral earnestness. If one adds to these no little ability in the art of wire-pulling for good causes one can understand why he attained an influence over the thought of his time that few men have had.

By comparison our own age seems half-hearted and disillusioned. Two great wars have shown us that a civilization highly developed in science and technology is still capable of behaving as irrationally and cruelly as a band of savages. One of Huxley's own gifted grandsons has revealed the kind of Utopia to which scientific progress can conceivably lead. We have lost the certainties and the simplicities of the Victorians, and it would no longer seem worth while for an eminent man of science to conduct a controversy with a prime minister on the credibility of the story of the Gadarene swine. The irrationalities of our time are more pervasive and infinitely more harmful than those against which Huxley fought. But if Huxley's beliefs seem in some ways over-simple, his vigour, his humanity, his belief that the scientist must show concern for the social and intellectual problems of his time, offer us a great example. Huxley stands as evidence of the fact that a scientist can also be a humanist and an educator, and Dr Bibby deserves our gratitude for making clear this triple contribution at a time when some such synthesis is so necessary.

JAMES OF RUSHOLME

STARS AND MEN

Of Stars and Men

The Human Response to an Expanding Universe. By Harlow Shapley. Pp vii+145. (London: Elek Books, Ltd., 1958.) 15s net.

DR HARLOW SHAPLEY, director of the Harvard College Observatory for more than thirty years, is a world-renowned figure in the fields of astronomy and cosmography. He has the not common gift of being able to write simply and lucidly for both scientist and layman. Dr Shapley begins by attempting an obituary of the anthropocentric view that man is the centre of the cosmos, and continues by interpreting the consequences to man (or rather to certain aspects of rational thinking) of the latest scientific discoveries in the cosmos. Dr Shapley's interpretation of man's position in the cosmos—a favourite theme since the writing of the first chapter of Genesis—is the latest and the best to date, but it will not prove to be the last. No doubt Dr Shapley deduces from our cosmological knowledge the best interpretation of our present generalizations, but only from the physical point of view. It is difficult to know how terrestrial man can ever do more than speculate on the existence of life on planets outside his own solar system. Interesting as all this is as a rational and speculative exercise, much of the issue is evaded. The nature of man as a spiritual being capable of high aspirations, of self-sacrifice, and the creation and appreciation of beautiful things, does not appear in Dr Shapley's picture to any great extent. This is not to belittle this book; within the framework which he honestly sets out at the beginning he has developed his story with logic, restraint and charm, but few people will think that it is the whole story.

Dr Shapley's displacement of human life from its once supreme position does not make him a pessimist, for he argues cogently that there must be at least a hundred million planets capable of supporting some form of life. Dr Shapley concludes his book with what he calls "a Martian look" into the future. He dismisses the prospect of the Earth's collision with a star, or of wandering from its orbit and getting too near or too far away from the Sun. Nor does he envisage a biological calamity wiping out the whole human race. The real danger is man himself, who is busy perfecting the tools for performing an operation which is unlikely to be performed by natural forces.

"Fish or *Homo*, that is the question. Which animal type will most certainly be here 10,000 years from now, and which will more likely fall the victim of fate and folly? The answer, of course, is too obvious. The fish have been here several hundred million years; man but a few thousand. ... But 10,000 years is a pretty long time for *Homo*. His structure and social manners do not make him a good insurance risk."

Much humanism is a weariness of the flesh and in the making of cosmologies there is no end, but Dr. Shapley avoids these pitfalls and has written a book which should stimulate and challenge every intelligent reader.

W. L. SUMNER

ASTROPHYSICS

Handbuch der Physik

Herausgegeben von S. Flügge. Band 50: Astrophysik 1: Sternoberflächen-Doppelsterne. Pp vii+458. (Berlin: Springer-Verlag, 1958.) 98 D.M.

THIS is the first of the five volumes of the new "Handbuch der Physik" which are to be devoted to astrophysics. Preliminary announcements show that a wide range of subjects is to be covered, excluding solar physics but including some of the most recent developments in other fields. However, the contributions in this particular volume deal mostly with the older parts of astrophysics, based on techniques well established before 1940 But they are none the worse for that, indeed, it is one of the weaknesses of present-day astrophysics that insufficient effort is being put into basic measurements such as are dealt with in several of these articles, for example, stellar masses and radii from visual and eclipsing binaries, atomic abundances from stellar spectra

Ch Fehrenbach has given a full account of the classification of normal stellar spectra P C Keenan has written briefly of stars with peculiar spectra, in a useful although not comprehensive article which contains material not readily obtainable elsewhere, for example, on high-velocity stars P. Swings's contribution on molecular bands in stellar spectra deals with a complicated subject in which much remains to be done and in which there is a scarcity of other publications Two useful contributions by K Wurm on planetary nebulae are widely separated in the book, although intended to complement each other I find it difficult to understand why they were not united J L Greenstein has written an important original paper on white dwarf spectra which is essential reading for anyone working in this field

P van de Kamp's article on visual binaries is to be commended It deals with a woefully neglected subject on which there is no modern text-book There follow accounts of eclipsing binaries by S Gaposchkin and of spectroscopic binaries by O Struve and Su-Shu Huang Eclipsing binaries are usually also spectroscopic binaries, both classes are very important sources of data for checking theoretical models, but the complications shown by their light curves and spectra have led to speculative ideas for which we have as yet no adequate check

The article by D Barbier is virtually a short text-book, giving a good systematic exposition of what may be called the conventional theory of stellar atmospheres and its very solid achievements

The articles are in English, French or German Each includes a brief general bibliography, in some cases with short comments Adequate attention has been given to other references also The index is in three parts German with an English translation, English with a German translation, and French only for the three articles written in French

As in every "Handbuch" of this character, the contributions vary a great deal in merit, the better ones are excellent Present indications are that this is to be one of the cheaper volumes, although its price is more than £8 R O Redman

ELECTRONICS IN BIOLOGY

Electronic Apparatus for Biological Research

By P E K Donaldson With contributions by Dr J W L Beament, F W Campbell, Dr D W Kennard, Dr R D Keynes, Dr K E Machin and Dr I A Silver Pp xii+718 (London Butterworths Scientific Publications, New York Academic Press, Inc, 1958) 120s, 20 dollars

To be able to use and interpret correctly the results obtained by using electronic apparatus, the biologist requires some understanding of electronics—a secondary subject which may have little direct appeal to him—and for this reason, a book explaining concisely the principles and functions of electronic apparatus used in biological research could be of great value The author of the book has had the needs of the biologist primarily in mind and he and his associate contributors, as members of the staff of the Department of Physiology at Cambridge, ought to be well qualified to look after his needs

The book is divided into four parts Part 1, principles of electronics (277 pp), Part 2, practical use of components (48 pp), Part 3, articles by specialist contributors on transducers, electrodes, indicators and measurement of temperature, light and radioactivity (249 pp), Part 4, complete apparatus (127 pp) The first part is of standard text-book form, with the exclusion of subjects considered to be of little interest to the biologist The treatment is brief, and in some cases, unfortunately, it is insufficient to permit one to follow applications which are given later The section on filters is too detailed for the reader wishing to be acquainted with, rather than fully to understand, the subject On the other hand, the application of the valve as a switching element is covered very briefly, and no mention is made of the pulse response of networks with reference to differentiation and integration The various sources of noise are analysed, this chapter being particularly useful in quoting orders of magnitude The graphs here are excellent and self-explanatory but could have been more conveniently placed in relation to the text, as has been done elsewhere In separating the information on batteries in Part 2 from the section dealing with stabilized power supplies, the opportunity to discuss their relative merits is missed

There are nine chapters in Part 3 dealing with specific subjects, all of which should prove useful to anyone concerned with biological instrumentation The theoretical treatment of light sources and detectors is well done, as also is the assay of radioactivity, but circuit applications would have improved both chapters The articles on electrodes, transducers and the use of relay circuits are valuable contributions, but that on temperature measurement could have been improved by a recapitulation of the physical principles

The important section of Part 4 dealing with apparatus is unfortunately condensed into only one-sixth of the book Stimulus artefact is explained very well, as is also the subject of interference, and all readers interested in design would benefit from the author's design procedure A chapter on transistors gives a useful introduction to the principles, but an assessment of their possible future in biological research would have helped to define their importance

The book is well written, and the practical advice given shows that the author writes from experience Its value could have been increased by linking the biological specifications to appropriate designs, an important feature of biological instrumentation The failure to achieve this linkage makes the book of rather limited value to the engineer who is designing apparatus for biologists However, in helping to satisfy the requirements of the physiologist, the aim of the author has been achieved, albeit at a high price In the preface the author expresses doubts about the suitability of the title, and since the emphasis is so much on physiological applications, the reviewer is of the opinion that "Electronic Apparatus for Physiological Research" would convey more precisely the nature of the subject-matter

W J Perkins

HISTORY OF TECHNOLOGY

A History of Technology
Edited by Charles Singer, E J. Holmyard, A R Hall and Trevor I Williams Assisted by Y Peel, J R Petty and M Reeve Vol 5 The Late Nineteenth Century, *c* 1850 to *c* 1900 Pp xxxviii + 888 + 44 plates (Oxford Clarendon Press, London Oxford University Press, 1958) 168*s*. net

THIS fifth volume of the "History of Technology", covering the approximate period 1850–1900, marks the conclusion of this great work, which traces the development of technology from the earliest times to the beginning of the present century In some fields brief reference is made in the present volume to developments that have taken place so recently as the years following the Second World War

The book is divided into eight parts The first deals with primary production, including the management of food and the development of the metal and petroleum industries The second part concerns itself with stationary and marine steam engines and the internal combustion engine Part 3 treats of the rise of the electrical industry , Part 4 of the chemical industry Part 5 deals with transport, including railways, ships, aircraft, road vehicles, and cartography and other aids to navigation Part 6 is concerned with civil engineering, and covers building materials, bridges, tunnels, hydraulic engineering and water supplies The seventh part discusses manufacturing in general, including textiles, metals, machine tools, ceramics, glass, printing, photography, and rubber The last part evaluates technological education and the general role of technology and its social consequences in the modern world

Each of the chapters is written by a competent authority, and the whole volume has been brought together and made into a unified work by its principal editor, the eminent Dr Charles Singer, and by Dr E J Holmyard and two other distinguished co-editors

Although it could not be expected that every one of the thirty-four chapters would delve with equal thoroughness into the mass of technological history behind each subject treated, nevertheless, the whole presents a most enlightening and valuable summary of progress during the crucial last half of the nineteenth century For example, two such different stories as the development of machines for the generation of electricity and the discovery of aniline dyes are almost breath-taking in their implications for later pure science as well as for technology

It is certain that many full reviews of this extensive and admirable work will be written in Great Britain The present American reviewer feels that he should devote special attention to the volume as it may appear to some American eyes First of all, it is impossible not to be struck by the clarity of exposition of the present work It is hard to believe that an equal number of American students in this field could be found who could write so well It is indeed surprising to find authorities in the highly specialized fields of technology who are able to present their subjects so lucidly The style of the volume will make it attractive even to the layman who is concerned with the full history of our age Anyone who is interested in reading present-day political or social history will also enjoy the style and the content of this volume Here the reader is not overwhelmed by mathematics or repelled by an unnecessarily technical vocabulary It has been possible for the editors to cover the really vast human achievement that is considered in this book only by exercising great verbal restraint Often a single sentence summarizes a large development that even in an encyclopædia article might have been given a long paragraph For example, Josiah Willard Gibbs, considered by some to be the man who did most for pure science underlying technology in America during this period, is described in four words as the formulator of the phase rule

I could not indeed read many pages of this book without thinking of the fascinating problem of national differences in the approach to scientific and technological history In recent years the world has noted successive Russian claims that very many of the great inventions and developments of the past really originated in Russia Similarly, one who walks through the Deutsches Museum in Munich must feel that the tens of thousands of earnest young Germans who go through its admirable halls each year must gain the impression that the full flowering of the industrial revolution took place almost alone in fertile German soil It is similarly apparent that the present volume quite properly emphasizes British science, technological inventions and developments This very fact makes the work especially valuable in America Many new industrial developments in the United States grew out of British beginnings, and this volume clearly portrays this essential background

Some day a general treatise on detailed technological developments in the United States will be prepared, and when it does appear, it will be a valuable supplement to the present volume When such a treatise is written, it will, for example, give full emphasis to the material contained in the voluminous publications of such organizations as Benjamin Franklin's still very active, learned academy, "The American Philosophical Society, Held at Philadelphia for the Promotion of Useful Knowledge" , the National Academy of Sciences of the United States , and the Smithsonian Institution It is indeed a little surprising to find no reference in the index to these American organizations, which were doing so much for world science and technology during this period, in spite of many references to the Royal Society, Royal Institution, and the Science Museum, South Kensington It is quite understandable, however, that the mass of American material could not be dealt with in a complete way in the present book, which is very properly British in its central emphasis

All five volumes of this great work, nevertheless, fill a need long and keenly recognized, especially, it may be, on the western side of the Atlantic Americans will long be deeply conscious, therefore, of the debt that they owe to the distinguished authors and editors of all five volumes of the work The book will be read with pleasure and satisfaction by everyone in the United States who is professionally concerned with the history of technology and, as already suggested, by many others as well In the years ahead these volumes will be among the reference books most frequently reached for on the working shelf of any student who is concerned with this area of scholarship An expression of gratitude is also due to the great Imperial Chemical Industries, Ltd , which helped to make possible the preparation of these expensive, well-illustrated, and well-printed volumes

LEONARD CARMICHAEL

THE WISTAR INSTITUTE OF ANATOMY AND BIOLOGY, PHILADELPHIA

By Dr R E. BILLINGHAM and Dr H KOPROWSKI (Director)

No institute is more deeply rooted in the history of American biology and medical science than the Wistar Institute of Anatomy and Biology of Philadelphia (Fig 1) Its opening in 1894 was made possible by the generosity of General Isaac J Wistar, a colourful figure in American history—sometime farm-worker, trapper, lawyer, company president and Union Army general Its primary purpose was to house a fine collection of anatomical specimens and preparations in the Hunterian tradition amassed, in part, over the years by General Wistar's great-uncle, Prof Caspar Wistar, doctor of medicine of the University of Edinburgh, professor of anatomy at the University of Pennsylvania, and in 1811 author of "System of Anatomy", the first and for long the standard anatomical text in America. The other distinguished contributor to this collection was Dr W E Horner, who was at one time dissector to Wistar and who later occupied the chair of anatomy

In addition to its museum, the Institute was equipped with laboratories and facilities to enable investigators to study comparative anatomy and experimental biology In 1923, a complete printing press organization was established on the premises so that the Institute could exert more efficient control over the well-known journals and publications bearing its imprint, some dating from 1908 The intensive investigation of the laboratory rat has been almost a Wistar prerogative for nearly half a century, indeed the albino rats from its large animal colony have probably propagated the name of the Wistar Institute throughout the world almost as effectively as its journals

Probably because of the changing emphasis in biological and medical research, the Institute's facilities became no longer adequate to attract those investigators who wished to work in the forefront of biological science, and its scientific contributions declined sadly In 1957, however, the Board of Managers appointed Dr Hilary Koprowski, a virologist, as director In the ensuing months, grants from the Federal Government, private enterprise and personal donations have been spent in modernizing the Institute in all respects and enlarging its scientific staff to its present level of fifty, which includes representatives of seven different nations

According to its statute book "The Institute will be open to any and every searcher for knowledge", and at present it has eight graduate research students who are enrolled at the University of Pennsylvania, which lies immediately across the street and in which several members of the staff hold academic appointments There are Wistar professors of microbiology, of research medicine and of zoology, and some associate and assistant professors Indeed, the loose affiliation between the Institute and the University of Pennsylvania is ideal for both organizations According to its deed of trust "the object of the laboratories and workrooms and of any lectures or instruction to be given at the Institute shall be for the improvement and research of postgraduate or advanced students and of searchers after new and original knowledge, and neither the Institute, its premises or property shall be used to replace or supersede such elementary instruction of undergraduate students as now does, or hereafter may fairly pertain to the ordinary or necessary curriculum of the University"

To commemorate the recent completion of the Institute's re-organization a symposium on "The Structure of Science" was held during April 17–18, and attended by more than five hundred biologists The subject of the first session was "National and International Research" The opening speaker, Mr Francis Boyer, president of Wistar's Board of Managers, stressed the important role still open for small, independent research institutes in contemporary science The Hon Lister Hill, United States Senator from Alabama, gave an account of the Bill which he recently introduced in Congress to create a National Institute of International Medical Research, as part of the National Institutes of Health This would be charged with the support of medical projects submitted by competent investigators from any part of the world Other speakers were Dr Leroy Burney, surgeon general, United States Public Health Service, who emphasized the extremely liberal conditions under which federal grants were made to research institutes such as Wistar, and Dr Detlev Bronk, president of the Rockefeller Institute and the National Academy of Sciences, who spoke of the importance of allowing investigators complete freedom of action in a world that is constantly clamouring for direction of research Finally, Dr Tuzo Wilson, professor of geophysics, University of Toronto, gave an illustrated account of his recent visit to "mainland" China and Formosa He said that the mainland Chinese were the hardest working people he had ever seen If their geophysical laboratories are a measure of their activity in other disciplines, it would not be long before they contributed fully to world science

The following session, subtitled "The Road to Knowledge", was opened by a paper on mathematical principles in biology by Dr Nicolas Rashevsky of the University of Chicago He said that hitherto it was only in genetics that mathematical biology had achieved a definite predictory and explanatory value After outlining the difficulties of attempting to apply or develop theoretical biology to explain organic form or complexity of organization—analytical geometry cannot take into account such a trivial event as a cat changing its posture—he outlined a "principle of optimal design", according to which the overall design is compatible with the highest degree of economy for a given set of physiological functions This concept had already been applied successfully to the design of the vascular system Dr Rashevsky then discussed the relationships between physico-chemical processes underlying super-

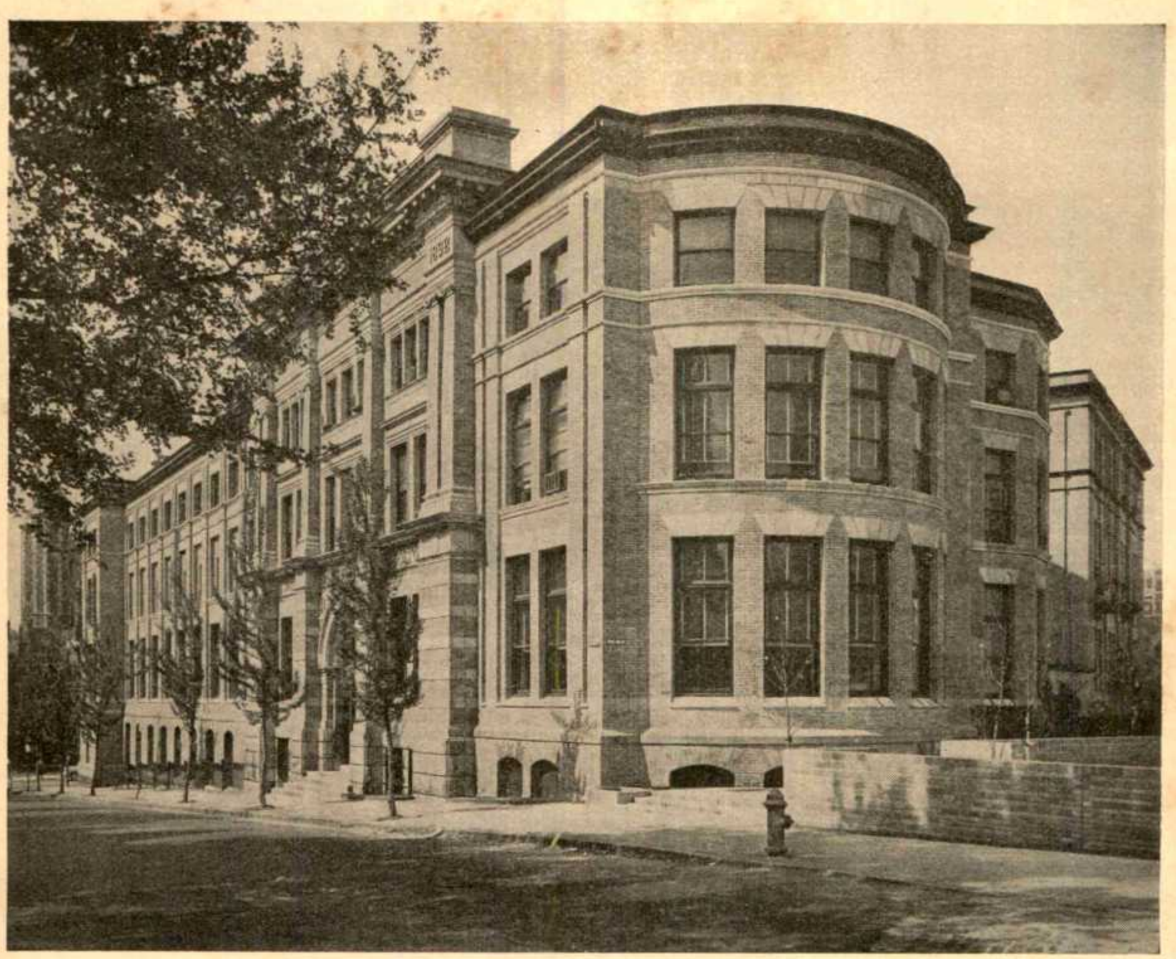

Fig. 1. The Wistar Institute of Anatomy and Biology, Philadelphia. The building, completely renovated in 1958–59, now houses new laboratories and equipment for its staff of fifty scientists

ficially comparable events in higher and lower organisms, and argued that despite their greater repertoire, the biological processes of higher organisms were interpretable in terms of the fewer properties of simpler organisms. He predicted that a unicellular organism will be found capable of producing antibodies to some specific antigens.

Dr. Ludwig von Bertalanffy, Sloan visiting professor at the Menninger Clinic Foundation, discussed the role of theoretical biology in integrative sciences. He stressed the inadequacy of the mechanistic approach derived from classical physics, which had as its goal the resolution of living things into component parts and processes, by analogy with machines. In the new philosophy the organism was no longer to be considered as being simply a reactive system, answering stimuli of extraneous origin in order to re-establish some sort of equilibrium. In Bertalanffy's own words, "the problems of organic wholeness, organization, teleology, and the like, which were taboo in the mechanistic world picture, are now taken seriously and approached as legitimate problems for scientific inquiry and theory".

Dr. Anatol Rapoport, professor of mental health, University of Michigan, in a witty and lucid consideration of the language of science, said that although most advanced branches of science had developed their own special languages, such as the molecular structural symbolism of chemistry, there was still a residue of "ordinary" language—its vernacular component. With particular reference to chemistry and physics, he argued that the language of science neither depended upon an extensive vocabulary nor was necessarily devoid of poetry. Key terms in higher algebra included 'group', 'ideal', 'trace', and fundamental words in physics were likewise simple—for example, 'field', 'orbit', 'nucleus'—yet it was impossible to explain the meaning of any of these words to anyone lacking considerable experience of the appropriate kind. In the language of science, very simple words were used to denote exceedingly complex concepts. Most of the terms in physics were defined by mathematical operations, for example, 'feet per second squared', in contrast to classical terminology which was translatable into visual images. This far-reaching innovation freed the intellect from dependence on literal conceptions and mathematical operations had largely taken their place.

Dr. Rapoport denied that the language of science was prosaic. It has its own metaphors: the 'osculating curve' (not an amatory function, but a mathematical form), the engineer's 'black box', the neurophysiologist's 'threshold', and the mathematician's 'primitive'. In conclusion, he brought up a most profound question of scientific philosophy—the metaphysical underpinnings of the language of science: Where was the borderline between knowledge and faith?

The last speaker of the session, Dr. Donald H. Andrews, B. N. Baker professor of organic chemistry in Johns Hopkins University, discussed new relationships between art and sciences. He developed an interesting idea on the analysis of form in terms of thermodynamics and entropy on one hand, and of information theory on the other. Citing as an example an unstruck piano string vibrating with overtones set up by its thermal energy, Dr. Andrews argued that a statue of marble probably had overtones "which in the harmonic realm are the exact equivalent, homomorphic with the space form". If this statue were cooled to within perhaps a 200,000th of a degree of absolute zero and its heat capacity measured and integrated as it was warmed very slowly, the entropy term would be obtained over the very lowest part of the temperature-range and would bear a direct relationship to the shape of the statue, based on the longest thermal vibrations, with wave-length a function of the shape of the statue.

In theory it should be possible to transmit 'space-form' information defining the statue over a distance via radio waves or telephone signals for reproduction at an appropriate lathe-assembly. Developing such new concepts of 'scientific æsthetics', Dr. Andrews concluded that perhaps a more faithful algebra of form was needed for many of to-day's problems, in thermodynamics, in the study of molecules and of molecular aggregates.

The speakers at the third session of the symposium concerned themselves with unifying principles in their respective fields.

Prof. P. B. Medawar, professor of zoology, University College, London, presented a critical account of the various possible theories which might account for the phenomenon of immunological tolerance—the specific immunological unresponsiveness induced by exposure of very young animals to antigens. After making two assumptions : (1) that the maintenance of the tolerant state depends on persistence of the antigen, and (2) that any one antibody-forming cell (and its descendant clone) responds to only one antigen at a time, he considered, in turn, a series of mutually exclusive postulates, for example, that immature antibody-forming cells capable of being made tolerant occurred (*a*) only in embryos or very young animals, or (*b*) in adults as well. He then went on to discuss the hypotheses one could arrive at by various combinations of postulates, one of which led logically to the view that while some cells in the adult became immunized by exposure to antigen, others must become tolerant.

Dr. Francis H. C. Crick, Cavendish Laboratory, University of Cambridge, spoke on the structure of viruses. He emphasized the multiplicity of factors which govern the aggregation or packing of identical units into a given space. In the simplest case, spherical sub-units are aggregated so as to occupy the smallest possible space. Such an array has certain elements of cubic symmetry. There are five-fold, three-fold and two-fold axes of symmetry. The surfaces of many viruses are polygonal with elements of 2-3, 4-3-2 and 5-3-2 symmetry ; in some of these evidence has been obtained of a regular array of sub-units. Apparently, the protein parts of many viruses are made up of roughly spherical sub-units assembled in such a manner as to occupy the least space.

Studies on infectious ribonucleic acid isolated from tobacco mosaic and certain mammalian viruses indicate, according to Dr. Crick, that the ribonucleic acid carries, at least in part, the necessary information to determine the amino-acid sequence of the protein sheath of the virus particle. However, since there are no known viruses consisting of less than 70 per cent protein, it is unlikely that the viral nucleic acid carries sufficient genetic information to determine such a large protein shell. The alternative is a large number of small, symmetrically packed, protein sub-units.

Dr. H. Gobind Khorana, University of British Columbia, showed how advances in our knowledge of organic chemical structures and of organic synthesis had contributed to an understanding of biological processes. He reviewed some of the important accomplishments in protein and peptide chemistry—such as the elucidation of the structure of gramicidin *S* and of oxytocic hormones. The determination of the total sequence of structural units in adrenocorticotrophic hormones and other biologically active materials should soon extend to the sequence in larger molecules such as ribonucleases.

Turning to research on intermediary metabolism, Dr. Khorana discussed the organic chemistry of phosphate esters, with particular emphasis on nucleotide co-enzymes, mentioning his own important work on the synthesis of co-enzyme *A*. He said that despite the underlying similarity in the structure of nucleotide co-enzymes, it was at present inexplicable and rather exciting that their specificity depends upon the nucleosides that they carry.

On another topic, the sequential analysis of nucleic acids, he emphasized the present need for research. He described the chemical synthesis of a number of oligonucleotides that would be useful in developing enzymatic degradation methods for structural analysis of nucleic acids. One problem which confronted us to-day, he concluded, was to match the sequential analyses of nucleic acids with similar analyses of amino-acids in proteins and polypeptides.

A lucid discussion of the mechanism of gene-action was presented by Dr. John R. Preer, University of Pennsylvania. He said that genes act by influencing the properties of proteins, probably because they are the determinant forms of the templates (usually held to be of ribonucleic acid nature) which direct protein synthesis. He felt that the original Beadle hypothesis of one gene : one enzyme should be extended to include protein and template, so that one would have one gene : one template : one protein.

The many different strain-specific ciliary proteins of *Paramecium* are particularly advantageous materials for the study of gene-protein relations. Many different loci with multiple alleles are involved in the determination of these proteins. Genes at only a single locus affect each type of protein, and a locus determining one type of protein is without effect on any other locus. This complex situation is explicable on the template hypothesis. Studies on the genetic determination of different types of hæmoglobin in man, which usually differ with respect to a single amino-acid, had furnished beautiful support for gene-amino-acid determination.

Dr. George Klein, Karolinska Institutet, Stockholm, gave a lucid analysis of the evolution of tumour cell populations. The change from a normal to a malignant cell was usually the result of a series of successive qualitative steps, known as tumour progression. The various unit characteristics of tumours such as growth-rate, sensitivity to drugs, invasiveness, etc., did not all change together during progression, but re-assorted independently so that each tumour appeared to undergo an evolution of its own, differing from other tumours on a combinatorial basis. The postulated unit characters were probably not interrelated, but were determined by different cellular mechanisms.

Dr. Klein discussed three of the many conceivable mechanisms which might account for progression: (1) the selection, by intrinsic or extrinsic factors, of new variant cell types differing from the original type with respect to one or more unit characters; (2) the loss of ability of cells to respond to homœostatic forces of the organism; and (3) automatic changes in cell population characteristics which might occur merely by virtue of an increase in the population and did not depend on cellular change. Like Lederberg, he felt that analysis of the mechanisms of progression should be modelled on techniques derived from microbial genetics.

The closing session of the symposium was devoted to papers presented by members of the scientific staff of the Wistar Institute.

Dr. Hilary Koprowski, director of the Institute, spoke of the staff as a group of independent thinkers of widely different backgrounds who approached their scientific problems in individualistic ways but worked together through an "intercommunicating system". The main object of research at the Wistar Institute, he said, was the study of cellular biology, or perhaps more accurately, "the study of the biological micro- and macro-cosmos and the attempt to bridge the gap between the two". He enlarged on this concept, saying that staff members were making quantitative studies at the cellular level and were attempting the difficult and hazardous task of applying knowledge about the cell to studies of the whole organism.

Dr. Angus F. Graham discussed general aspects of cell-virus relationships and the methodology of their analyses. He had been developing an *in vitro* virus-mammalian cell system in fluid suspension, by means of which it might be possible to investigate quantitative aspects of virus infection in a manner analogous to studies with the classic phage-bacteria system.

Dr. Eberhard Wecker presented evidence that the infectious ribonucleic acid which he extracted by the usual phenol technique at 4° C. from cells infected by eastern equine encephalomyelitis or western equine encephalomyelitis was not derived from the virus elementary bodies themselves but from a virus precursor which appeared in the infected cells before the mature virus particles. Although lipid-containing mature virus particles did not yield infectious ribonucleic acid on treatment with phenol at 4° C., Dr. Wecker reported a successful extraction at higher temperatures (40–50° C.). He concluded by indicating how ability to distinguish between the precursor of ribonucleic acid and the acid itself from mature virus particles might lead to a better understanding of the biosynthesis of viruses within cells.

Continuing the discussion of viral nucleic acids, Dr. John S. Colter outlined studies made in collaboration with Dr. Kay Ellem. By a modification of the classic Gierer and Schramm phenol extraction technique for ribonucleic acid, in which cells were disrupted in solutions of high instead of physiological ionic strength, the deoxyribonucleic acid was extracted in the aqueous phase, while the bulk of the ribonucleic acid was eliminated into the phenol phase. The final product was free from protein and ribonucleic acid, and the yield was quantitative.

By adding sodium desoxycholate, the recovery of infectious ribonucleic acid by Gierer and Schramm's phenol extraction method from Ehrlich ascites cells infected with Mengo or West Nile viruses was greatly improved—possibly even five-fold. A collateral study of the ribonucleases of normal and malignant murine tissues implicated the pancreas as the source of the enzyme. Because of the existence of a ribonuclease inhibitor the pattern of ribonuclease activity of ascites tumour cells differed markedly from that of a normal tissue. The possible role of the magnesium ion as an inactivator of ribonuclease activity was discussed.

Dr. Raymond A. Brown outlined the biophysical properties of the preparations of deoxyribonucleic acid isolated by Dr. Colter's new method. The molecular weight was four to five million, and its sedimentation constant and intrinsic viscosity values were lower than those usually quoted for deoxyribonucleic acid.

His own electron microscope studies led Dr. Brown to consider cellular ribonucleic acid to be made up of two types of molecules, both 42–43 A. in diameter but differing in length. There was suggestive evidence of a periodicity in the location of the phosphate groups along the axis of the rod. Each rod probably consisted of a tightly coiled single polynucleotide chain. At low ionic strength, the molecule uncoiled.

Dr. Vittorio Defendi discussed the virus-host cell relationships of two tumour-inducing viruses: the *RPL*-12 virus of the lymphomatosis tumour of chickens and the polyoma virus in hamsters. He described the necrotic and proliferative lesions of *RPL*-12 virus infection in tissue cultures, in chick embryos and in hatched chicks, emphasizing particularly the derangement of deoxyribonucleic acid metabolism which occurred during the infection.

He then outlined his findings on the pathogenesis of tumours arising in Syrian hamsters following their inoculation at birth with polyoma (parotid gland) virus. All the tumours were of identical histological type regardless of their location. Preliminary analysis of the infectability of newborn hamsters with the virus suggested that immunological tolerance is involved. For example, inoculation of newborn animals with the virus along with isologous adult lymphoid cells resulted in a greatly decreased proportion of tumour-bearing hamsters, and there was an amelioration of the course of the malignant disease in the minority of animals in which tumours did appear.

Drs. Rupert E. Billingham and Willys K. Silvers described their studies on the tissue transplantation antigen determined by a locus on the *Y* chromosome in male mice. This antigen was responsible for the rejection of male skin isografts by females in many inbred strains. Female mice of the *C*57 strain could be made tolerant of subsequent male isografts by inoculation with male cells as late as 17 days after birth, and tolerance in females could also be induced by means of cell-free antigenic extracts prepared from isogenic male tissues. Employing the principle of immunological tolerance they were able to show that all male mice, irrespective of their genetic constitution, possessed exactly the same *Y* chromosome antigen. This conclusion followed from the finding that *C*57 females injected at birth with cells from males of any other strain are invariably made tolerant of male skin isografts. A *Y*-chromosome antigen was also present in male rats, which preliminary results indicated was exactly the same as in the mouse.

Concluding the symposium, Prof. Sven Gard, Karolinska Institutet, Stockholm, and visiting member of the Wistar Institute (1958–59), gave warning against the general tendency to over-estimate the potentialities of pure biochemistry The activities of a living cell as seen under the microscope immediately dispelled any idea that it might be regarded as a bag of enzymes The fine structure of the cell with its innumerable surfaces and membranes offered a clue to the fundamental question: "Why and how do reactions occur in the right place at the right time?" The multiplicity of interests disclosed by the staff members of the Wistar Institute, and its strong tradition for morphology should guarantee concentric attacks on essential biological problems

THE AUSTRALIAN ACADEMY OF SCIENCE

On May 6, the Governor-General of Australia, Field-Marshal Sir William Slim, opened the new building which houses the offices and conference chamber of the Australian Academy of Science The establishment of the Academy was initiated by a group of Fellows of the Royal Society of London resident in Australia (*Nature*, 170, 549, 1952) With the help of other Australian scientific leaders, they set up a body which received a Royal Charter personally from Her Majesty Queen Elizabeth II during her Australian tour in 1954

The Australian Academy of Science is the representative body of Australian scientists at the national level, with functions comparable with those of the Royal Society of London, which was itself represented at the opening, on May 6, by its senior vice-president, Sir Lindor Brown The fellowship of the Academy now numbers eighty-seven and up to six new Fellows are elected each year The president of the Academy since 1957 has been Sir John Eccles, professor of physiology in the Australian National University, Canberra, his predecessor was Sir Mark Oliphant, director of the Research School of Physics in the National University

In outlining the history of the Academy, Sir John Eccles said that the need for a national scientific body of the highest standing led in 1919 to the formation of the Australian National Research Council, and thanks to the devoted efforts of its leaders, the Council gave most valuable service to Australia Yet it would be generally agreed that it had failed to achieve the status that was required of a national body with such weighty responsibilities Various efforts at internal reforms of the Council proved to be impracticable and a more radical proposal emerged from a conference on "Science in Australia" organized by the Australian National University in 1951 At this conference and in the subsequent discussions there was a fairly general agreement that an Academy of Science with much more restricted membership should replace the National Research Council The Council's executive with great magnanimity agreed to its dissolution in order to make way for the new Academy This was a fine act of self-sacrifice made in the belief that the new Academy would be better fitted to give leadership in the scientific development of Australia

The new Academy chose to model itself closely on the Royal Society of London, so taking advantage of three centuries of wisdom The Academy is also especially indebted to the Royal Society for help in its petitioning for the Royal Charter, and for the gift of a magnificent Signature Book that is a replica of the original Signature Book of the Royal Society

From the very beginning it has been of prime importance to ensure that the highest standards were maintained in the election to the fellowship, and that it was truly representative of all aspects of pure and applied science It could be claimed that it has retained the confidence of the general body of scientists in Australia

The functions of the Academy are both national and international At the national level there are certain general responsibilities in the fostering of science and in its publication However, it is at the international level that the Academy has its principal opportunities and functions First, it is the body representing Australia at all the international scientific unions as well as at the Pacific Science Congress and the Pan Indian Ocean Congress Secondly, it undertakes international scientific tasks for Australia The most notable has been the International Geophysical Year, the Academy being responsible for Australia's fine contribution From the International Geophysical Year there have developed further important international activities in which again the Academy represents Australia The Special Committee for Antarctic Research and the Committee for Space Research are of vital interest to Australia, and both have achieved a high status The third meeting of the Special Committee for Antarctic Research was held in Canberra this year and was generally agreed to be very successful Among other achievements was the inauguration of the International Antarctic Analysis Centre as an annex to the Bureau of Meteorology in Melbourne Other international activities are the organization of specialist international scientific meetings in Australia In August a specialist biochemical meeting on hæmatin enzymes was held at the Academy It is a field in which Australia holds a high place, and many of the leaders in other countries went to Australia for the conference Next year the Academy is arranging for an international conference on the chemistry of natural products, which will be held in Melbourne, Sydney and Canberra

In all these national and international activities the Academy can count on the devoted service not only of its own fellowship but also of the other scientists of Australia The aim is to select the scientists best fitted for these special purposes regardless of their affiliation with the Academy On the Standing and National Committees of the Academy the Fellows are outnumbered, and often scientists who are not Fellows hold key positions

There will be no relaxation of labour now that a centre for science has been established in Australia It has fine symbolism with its geometrical form and its great restraint of line and décor The Academy can now and in the future radiate its influence over Australia and the world and receive from the world for Australia But every end is a new beginning, and the Academy is now planning to become as well a channel for benefactions for scientific purposes and so to exert its influence not only through expert committees and individually by its Fellows but also

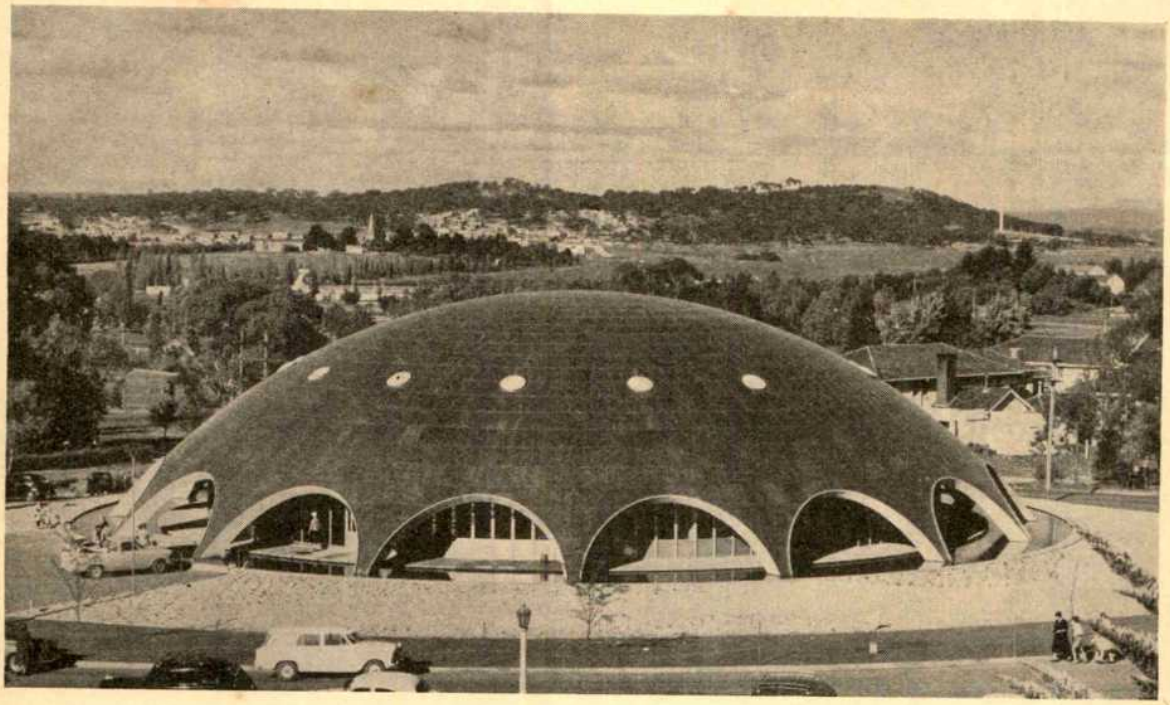

Fig. 1. New Building of the Australian Academy of Science, in Gordon Street, Canberra

by providing the finance for research projects. Benefactors would be secure in the knowledge that their contributions were being administered by the collective scientific wisdom of the Academy, rather than by the authority of any one scientist, however eminent.

The copper-sheathed dome of the new Academy building (Fig. 1), rising from the waters of a surrounding moat, is backed by the rolling bronze-green hills of Australia's national capital, Canberra. Beneath the dome is a central conference chamber, with luxurious seating for 190 and comfortable seating for a further 100, and a ring of offices, council room, and a superb reception room which overlooks an expanse which will within a few years be part of the central lake-system of Canberra. The conference chamber will be the venue of the annual meetings of the Academy itself, and will be extensively used for meetings of Australian scientific and professional societies, as well as for such international symposia as may be held in Australia.

The national responsibilities of the Academy receive material recognition from the Commonwealth Government in the form of an annual grant towards current expenses. The Academy, however, remains autonomous, and indeed the value of its services is derived very largely from its autonomy. It is too young a body to have achieved financial self-sufficiency through endowments; but the erection of the conference chamber and offices has been made possible entirely because of generous contributions to the Academy building fund by Australia's great industrial firms. To these firms, to the architects, and to the vision and energy of the members of its early Councils, the Australian Academy of Science, and Australia, owe a debt of gratitude; for they have created one of the most striking and important structures in Canberra, and they have provided the Academy with a home of its own which is modern, dignified, and of the highest quality.

MERLIN; AN INDUSTRIAL RESEARCH REACTOR

By Dr. T. E. ALLIBONE, F.R.S.

Research Laboratory, Associated Electrical Industries, Ltd., Aldermaston Court, Berkshire

THE *Merlin* research reactor is situated at the Research Laboratory of Associated Electrical Industries, Ltd., at Aldermaston Court in Berkshire. It was made critical for the first time on July 16, 1959.

The decision to install a reactor for fundamental research at Aldermaston was taken in 1955 and the Associated Electrical Industries–John Thompson Nuclear Energy Co. undertook to supply it. The nuclear physics aspects of the reactor and the design of the control system have been the responsibility of the Associated Electrical Industries Research Laboratory; the mechanical engineering design, the erection and the commissioning of the equipment up to the stage of loading fuel into the reactor have been the responsibility of Associated Electrical Industries–John Thompson. Loading of fuel began on July 6 by the staff of the Laboratory, who are now engaged on the proving trials of the reactor. These trials, which involve thermal, mechanical, electrical and physical measurements, will extend into 1960, while the reactor power is gradually increased to a maximum of 5 MW.

The original design of the reactor was for a maximum thermal power of 1 MW. However, the shortage of test facilities in research reactors in the United Kingdom was impressed upon Associated Electrical Industries, Ltd., by the Atomic Energy Authority, and inquiries from overseas indicated that a 5 MW. reactor was a more likely export, so the design was altered to achieve a power of 5 MW. type which is characterized by a large maximum fast *Merlin* is of the light-water-cooled and moderated (> 1 MeV.) neutron flux per unit of power. The maximum unperturbed fast flux with 3·4 kgm. of uranium-235 in the core is 6×10^{13}/cm.^{2}/s.; the average fast flux in the nuclear power reactors being built for the Central Electricity Generating Board is about 10^{12}/cm.^{2}/s. Because it is the fast neutrons which contribute a large portion of any irradiation damage to materials in a reactor, it should be possible to carry out life tests on materials subject to radiation in power reactors. It is believed, therefore, that *Merlin* will be a very useful addition to the research and testing reactors in the United Kingdom.

A view of the reactor as seen from the experimental floor is shown in Fig. 1. The reactor has been described in detail elsewhere[1]; it is of the pool type, using fuel highly enriched in uranium-235 suspended in a tank of light water. The minimum cold, unpoisoned critical mass of the reactor has been shown in subcritical experiments to be about 2·6 kgm. of uranium-235[2], from which the mass of uranium-235 required to provide a reactivity of 0·055 is calculated to be about 3·4 kgm. With a beryllia reflector, 3 in. thick, added around the vertical sides of the core the corresponding masses of uranium-235 are estimated to be 2·18 kgm. and 2·87 kgm., respectively. The maximum reactivity of the core has been limited to 0·055 for safety reasons. The maximum unperturbed thermal neutron flux with 3·4 kgm. of uranium-235 in the core is 5×10^{13}/cm.^{2}/s.; the average thermal flux in the Central Electricity Generating Board power reactors is about 2×10^{13}/cm.^{2}/s.

The reactor is unusual in that the core can be moved vertically to four positions. The top position permits the addition or withdrawal of fuel or experimental apparatus from the core; the moving core structure can be seen in Fig. 1 as it appears from the top floor of the reactor building when the core is in its highest position. At two lower positions the core is in the plane of sets of experimental facilities, which can be seen in Fig. 2. The lowest position is for storage of the core and is so arranged that the possibility of loss of coolant from the tank in this region is negligible.

The area occupied by the reactor and its associated buildings is close to Aldermaston Lake. The large building contains the reactor and the main experimental area, the reactor control room, the fission-product detector and the ventilation plant for the building. Nearer the lake is the primary coolant pump house, the secondary coolant pump house, a

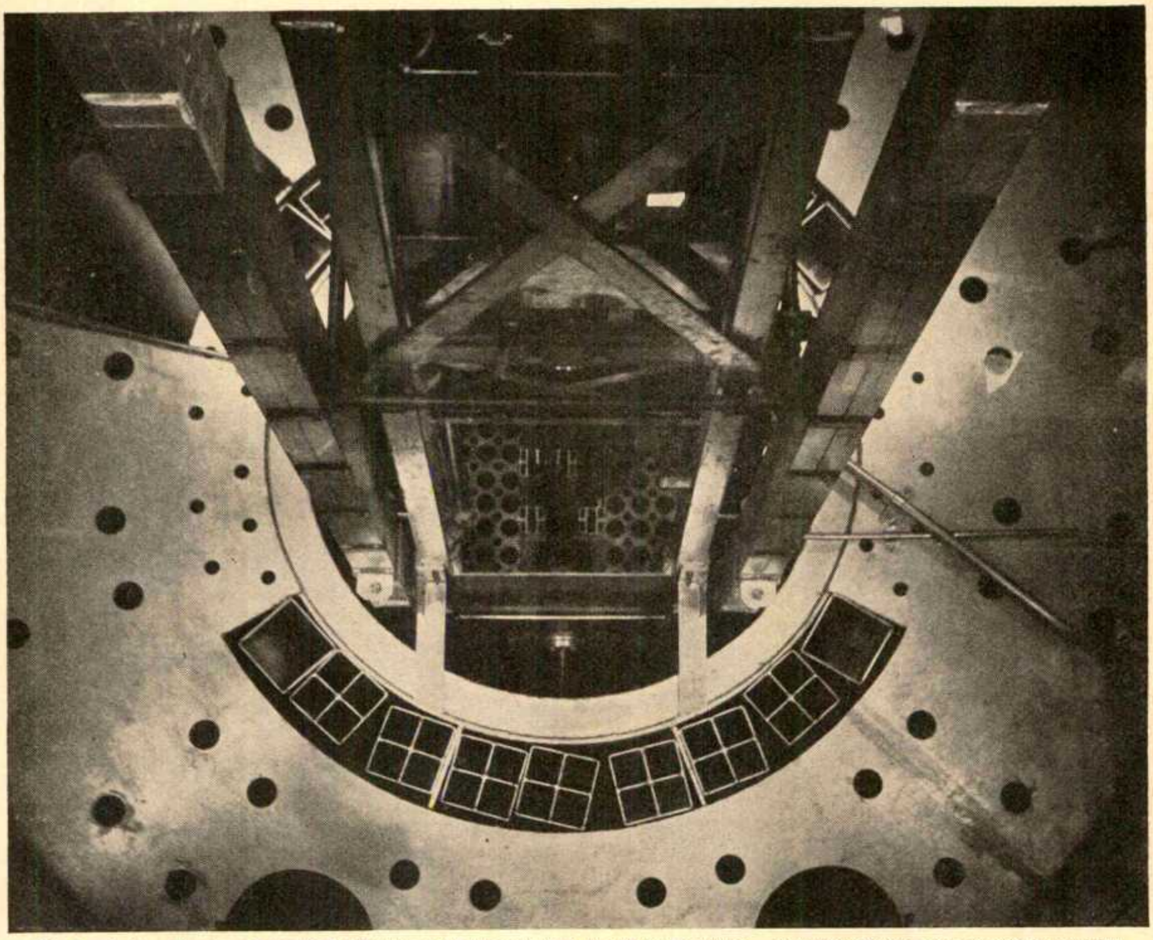

Fig. 1. A view into the reactor tank with the core lattice plate at its highest position. Four fuel elements can be seen in position on the lattice plate. The rectangular containers, in the foreground, are for temporary storage of active fuel elements

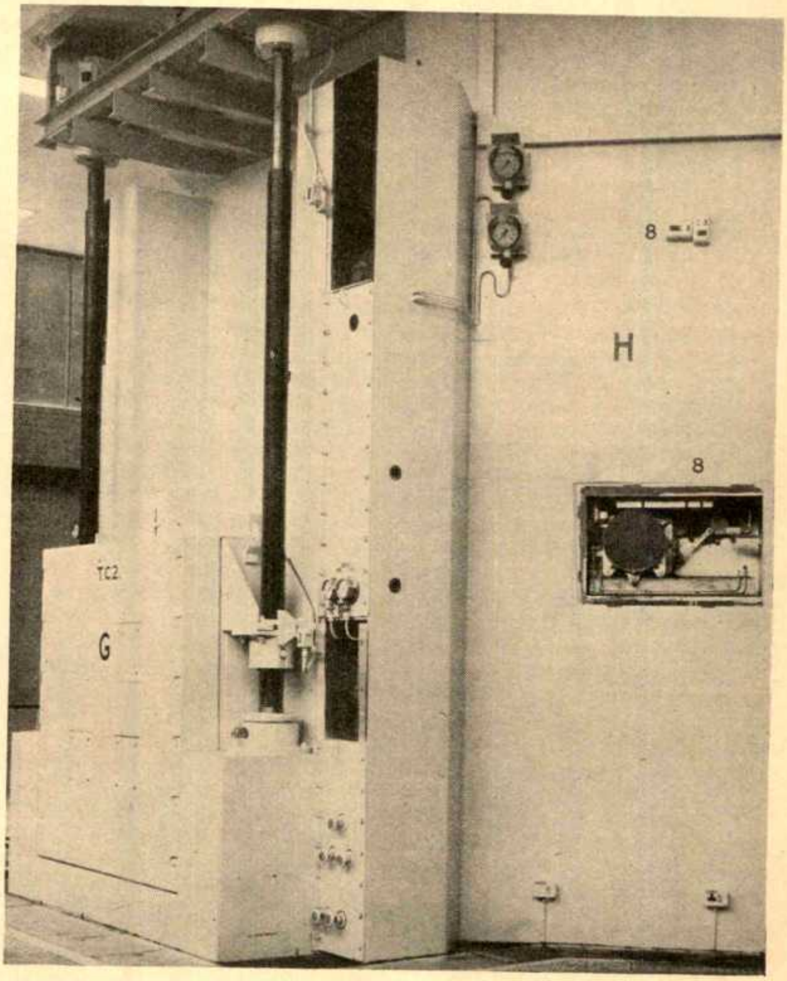

Fig. 2. The reactor and its experimental facilities as seen from the experimental floor

laboratory for sub-critical studies of the reactor core, an effluent plant for processing liquid effluent by filtration and ion-exchange before disposal and a personnel change room for use when entering and leaving the area in which contamination might occur. Four further small laboratories and offices are between the reactor and the lake. Twenty fixed radiation monitors are situated at positions throughout the buildings and in the effluent discharge system, and a further four monitors are situated approximately symmetrically around the reactor, at a distance of several hundred yards, to provide a warning of any undue release of airborne radioactivity.

The proposed research programme for *Merlin* covers both the fundamental and applied aspects of reactor research. Fundamental research being planned includes: the provision of nuclear data, the effects of radiation on materials, a study of Čerenkov radiation in reactors, and methods of measuring neutron spectra. The applied aspects of the research, which will certainly involve some fundamental work also, include: activation analysis, reactor control and safety studies, and the production of short-lived radioactive isotopes.

The Universities of Birmingham, London, Oxford, Reading and Southampton have been invited to consider how they might best use the reactor for the instruction of senior undergraduate and postgraduate students. Members of several university departments and of large polytechnics have spent several weeks with the reactor team, and during this summer a number of postgraduate students from the universities will be working in the laboratory on some research project associated with *Merlin*. University departments have been invited to arrange brief visits to the reactor for final-year students in physics, metallurgy and engineering, and longer visits for postgraduate students.

Dr. A. J. Salmon is the section leader in charge of the project, and the detailed work in the physics, electrical and mechanical engineering of the reactor has been the responsibility of Dr. K. Firth, Mr. B. Millar and Mr. I. Munro, respectively. The Reactor Section, together with the Thermonuclear and Nuclear Physics Section, constitute the Nuclear Sciences Group led by Mr. D. R. Chick, who is also responsible for the overall safety from nuclear hazards. Mr. J. N. Barnett, the Laboratory supervising engineer, has been responsible for the lay-out of this site, with Messrs. Atkins and Partners acting as consultants.

[1] Allibone, T. E., Chick, D. R., Firth, K., Millar, B., Munro, I., and Salmon, A. J., Geneva Conference Paper No. 313 (1958).

[2] Chick, D. R., Firth, K., Kerridge, M., and Salmon, A. J., *Nature*, **181**, 1171 (1958).

NEWS and VIEWS

Sir Owen Wansbrough-Jones, K.B.E., C.B.

At the end of September, Sir Owen Wansbrough-Jones is resigning from the position of chief scientist to the Minister of Supply. After taking his Ph.D. in the Department of Colloid Science at Cambridge, he spent some time with Hahn in Berlin. He returned to Cambridge both to his old department and to his college, Trinity Hall. There were excellent prospects of a brilliant academic career before him but, just as with his brother, he felt the call to the Army. He succeeded Sir Charles Ellis as scientific adviser to the Army Council. It has been said that the number of civilians who can understand the Army can be counted on the fingers of one hand. Wansbrough was certainly one of them. After some years of close contact with the Army Staff, he realized that he would serve them best by doing his utmost to ensure that the Army gained the weapons that they needed and he consequently moved over to the Ministry of Supply. During Wansbrough-Jones's period of office there has been a notable growth of the scientific spirit in the Minister's establishments. Under his stimulus the research and development work carried out in the Ministry has proved exceptionally fruitful, and is probably better in spite of national economic conditions than anything like it in the world. His colleagues will miss him greatly in his retirement.

The U.S. National Radio Astronomy Observatory : Prof. Otto Struve, For.Mem.R.S.

PROF. OTTO STRUVE has been appointed the first director of the National Radio Astronomy Observatory, Green Bank, West Virginia. The Observatory is being constructed and will be operated by Associated Universities, Inc., under contract to the National Science Foundation. Prof. Struve is at present professor of astronomy in the University of California and has been director of the Leuschner Observatory since 1950. He assumed his duties on July 1. An astronomer of international reputation, he has published approximately a thousand papers concerned with the problems of stellar spectra and other aspects of astrophysics. Although his principal scientific interest has been his important research on the properties of variable stars, his interests have extended more generally over the whole field of astronomy.

The National Radio Astronomy Observatory has been designed to supplement facilities available to research scientists of the universities by making available large and precise radio telescopes not hitherto available to American astronomers. Among these new instruments are the 85-ft. Howard E. Tatel precision radio telescope recently put into operation, the 140-ft. radio telescope now under construction, and a variety of auxiliary devices for radio astronomy. The Observatory is operated by a small permanent staff in co-operation with an increasing number of visiting scientists from various parts of the world.

1964 Olympic Games : Prof. Ryotaro Azuma

THAT the 1964 Olympic Games are to be held in Tokyo is largely due to the efforts of Ryotaro Azuma, formerly professor of pharmacology in the University of Tokyo, who was recently elected governor of Tokyo. Azuma, a distinguished member of the Japanese scientific community, has always encouraged the Olympic ideal of friendship and sportsmanship in international relations. He is a keen sportsman himself—he has rowed for the University of Tokyo; he also introduced the 'shell' to Japan from Britain, where he studied at University College, London, during 1922–24. Azuma is a member of the International Olympic Committee and in 1947 he was asked to head the Japan Athletic Federation. He played an important part in organizing the Asian Games which were held in Tokyo in 1958. Under his leadership sports for enjoyment, as opposed to sports as a form of regimentation, have had an immense success in Japan. Azuma sees a very close connexion between sport and Japan's post-war constitution renouncing militarism; but in his own words: "We must still educate the younger generation that it is not a disgrace to lose if you do your best".

Overseas Research Council

THE Overseas Research Council promised at the Commonwealth Trade and Economic Conference at Montreal last September has now been established. In a statement in the House of Lords, Lord Hailsham said that the Council, of which Dr. R. S. Aitken will be chairman, will provide a central point to which Commonwealth Governments and research institutions can refer for advice and information, and it will advise generally on United Kingdom co-operation in scientific research overseas. There are no geographical restrictions in the Council's terms of reference, and matters concerning scientific development in Colonial territories, in Commonwealth countries and in countries outside the Commonwealth, can equally be referred to it. Moreover, in promoting such development Lord Hailsham said the Council could look to possible collaboration between Great Britain and other Commonwealth countries, countries outside the Commonwealth, such as the United States, and international agencies, such as those of the United Nations and the charitable foundations. Asked whether the members would be paid, Lord Hailsham said he would require notice before replying in detail but he believed certain officers might be paid. There would be a certain amount of travelling and the members of the Council had been selected largely for their knowledge of overseas territories and connexions with science in them.

The other members of the Council are: Sir Jock Campbell, Sir Charles Dodds, Sir Harold Himsworth, Sir Joseph Hutchinson, Dr. R. Lewthwaite, Prof. J. McMichael, Sir Harry Melville, Mr. E. D. W. Nye, Sir Arnold Plant, Sir William Slater, Dr. H. G. Thornton and Sir Solly Zuckerman. The Council will advise the Privy Council Committee on Overseas Research, which consists of the Lord President of the Council and the Secretaries of State for Commonwealth Relations, the Colonies and Foreign Affairs. Its terms of reference comprise advice on the formulation of United Kingdom policy in respect (*a*) of scientific research undertaken in or for overseas territories within or without the Commonwealth, (*b*) of methods of making the results of research available in these territories, and (*c*) of assistance to the scientific services of these territories; on the co-ordination of the activities of United Kingdom Government organizations in the development of science in the civil sphere in overseas territories; and on co-operation within the Commonwealth, with other countries and with international agencies in promoting such development.

National Institute for Research in Nuclear Science

CONTRACTS for more than £430,000 have been placed by the National Institute for Research in Nuclear Science for the manufacture of the magnet coils required to energize the 7,000-ton electromagnet of the 7,000-MeV. proton synchrotron. This machine, which has been named *Nimrod*, is being built for the Institute by the United Kingdom Atomic Energy Authority at the Rutherford High Energy Laboratory, Harwell. Contracts have been awarded to British Copper Refiners, Ltd., of Prescot, Lancs., for the supply of more than 300 tons of refined copper (from which the coils are to be made), in the form of cast billets; to James Booth and Co., Ltd., of Birmingham for extrusion of the cast copper into hollow rectangular bars; and to Metropolitan-Vickers Electrical Co., Ltd., of Manchester, for the manufacture of the finished coils from the extruded bars. The Institute has also awarded a substantial contract to Marston Excelsior, Ltd., of Wolverhampton, for the development and supply of the reinforced plastic vacuum chamber in which the protons are accelerated. This chamber will be one of the largest plastic structures ever made.

Extension to the Chester Beatty Research Institute

On July 16, Sir Chester Beatty laid the foundation stone of an extension to the Chester Beatty Research Institute. The cost of the extension (£200,000), which will double the existing accommodation, is being defrayed from a trust fund deriving from the charitable public, and administered for the benefit of the Institute by the Board of Governors of the Royal Marsden Hospital. A contribution of £40,000 has also been made by the Wellcome Trust, in respect of which the extension will include a Wellcome Laboratory of Pharmacology and Experimental Chemotherapy. The Research Institute of the then Cancer Hospital, established in 1909–10 and opened in 1911 by H.R.H. the Duke of Connaught, was directed successively by the late Dr Alexander Paine, Dr Archibald Leith and Sir Ernest Kennaway. In 1938, Sir Chester Beatty (who was then president of the Hospital) bought, equipped and presented the existing building, which thenceforth became the Chester Beatty Research Institute. The Institute is now part of the Institute of Cancer Research: Royal Cancer Hospital, which in turn is a school of the University of London, and an institute of the British Postgraduate Medical Federation. The Institute obtains its main support from the Medical Research Council and the British Empire Cancer Campaign, and donations and legacies are received from the public. Generous help has also been given by the U.S. Public Health Service and other American sources such as the Jane Coffin Childs Memorial Fund for Medical Research and the Anna Fuller Fund of New Haven, and the Rosenstiel Foundation of New York City. The new building, of which the architects are Messrs Lanchester and Lodge, will be formally opened in 1960, when the Institute celebrates its jubilee year.

First Atomic Merchant Ship

The special illustrated supplement to the June 20 issue of *Atoms for Peace Digest* is devoted to a detailed description of the N.S. *Savannah*, the world's first atomic merchant ship, which was launched by Mrs Eisenhower on July 21, at the New York Shipbuilding Company's Yard in Camden, N.J. The *Savannah*, a joint project of the U.S. Maritime Administration and the Atomic Energy Commission, has been built mainly to promote the peaceful uses of atomic energy and will not be commercially competitive. The vessel is named after the S.S. *Savannah*, the first steam ship to cross the Atlantic, which started her voyage from Savannah, Georgia, to Liverpool on May 22, 1819, and is a combination passenger–cargo vessel, 595 ft long, with a beam of 78 ft. She can carry 9,500 tons of cargo and accommodate 60 passengers, and will be manned by a crew of about 100. Her speed is estimated at 20¼ knots. The *Savannah*'s reactor consists of a system of advanced design using pressurized water as a coolant and moderator, and fuel elements with about 4 per cent uranium-235 enrichment. The active core, which is 66 in. high and 62 in. mean diameter, contains the fissile material—7,050 kgm. of uranium oxide in 32 fuel rods, clad in stainless steel. There is a surrounding pressure vessel, primary shield, containing vessel and secondary shield, of 2,500 tons total gross weight. The reactor will supply 74 MW. of heat, providing sufficient power for the vessel to operate for about three years and to sail 300,000 nautical miles without refuelling. It is being built by Babcock and Wilcox at Lynchburg in Virginia at a cost of about ten million dollars. The total cost of the ship will be about 40 million dollars.

Labour Statistics

The Interdepartmental Committee on Social and Economic Research has recently issued a revised version of its guide to the statistics collected by the Ministry of Labour and National Service (Guides to Official Sources. No. 1, Labour Statistics. H.M. Stationery Office, London, 1959. 5*s*.) The opportunity has been taken to bring the material in the original edition up to date and to include a historical section, showing the development of labour statistics in Britain since the end of the nineteenth century. The topics covered include statistics of employment, unemployment, placings and vacancies, miscellaneous man-power statistics, wage rates, earnings and actual hours worked, strikes and industrial disputes, industrial accidents, the cost of living, retail prices and family budgets. Each of the sections is followed by a comprehensive bibliography of official sources.

World Distribution of Atmospheric Water Vapour Pressure

The Meteorological Office is much more than a forecasting institution. It is the public repository of knowledge regarding the weather, and among its many functions is the provision of data on a world-wide scale for a variety of users. "World Distribution of Atmospheric Water Vapour Pressure", by G. A. Tunnell (Geophysical Memoirs, No. 100. Pp. i+61. M.O. 584*h*. London: H.M. Stationery Office, 1958. 10*s*. net) is an atlas of the distribution over the whole world of the daily mean of atmospheric water vapour pressure for the months January, April, July and October, based on records from 3,500 stations. There follows a brief survey of the world distribution of diurnal variation of vapour pressure in different climates. Information concerning atmospheric humidity in all parts of the world is thus available in compact form for industrialists and others who may require it. Mapping is done by means of isopleths. In common with all such maps, the distributions so revealed have many interesting features not always readily explained. For example, taking account of the characteristics of Russia, is the breadth of the patch of higher vapour pressure shown both in January and July near Kazan real ? The midsummer variations in the mean vapour pressure over South Australia are also noteworthy. An agreeable publication, clearly printed, informative, and stimulating in respect of the distribution shown; the policy of the Meteorological Office in producing such memoirs will be widely welcomed.

The Customs and Religion of the Ch'iang

The Ch'iang inhabit a mountainous region in Szechwan in western China and grow maize as the main crop. They speak a Burmese–Tibetan language and are said to have formerly lived in north-eastern China. For some time past, however, they have been losing their own culture and adopting that of the Chinese, with whom they were earlier in conflict. We have such meagre information on the non-Chinese population of China that almost any report is of value. Mr D. C. Graham (Smithsonian Miscellaneous Collections, 135, No. 1: The Customs and Religion of the Ch'iang. Pp. vii+114+16 plates

Washington, D C Smithsonian Institution, 1958) has collected a considerable amount of material in the course of various expeditions to the area between 1925 and 1948 This he presents in a straightforward manner, and although he has little acquaintance with anthropological literature he does at least lay two ghosts assiduously fostered by another missionary, the Rev Torrance, who had claimed not only that the Ch'iang were monotheists but that they were also descended from one of the far-ranging tribes of ancient Israel On the positive side, scholars will be grateful for the information on religious beliefs and practices, particularly the eye-witness account of the ceremonies in the sacred grove As in many other parts of the world, these rituals provide some inclusive focus for the village as a whole, while the ancestral cult serves a similar function in respect of the constituent descent groups

Australian Mammal Society

At the Australian and New Zealand Association for the Advancement of Science meeting in Adelaide, held during August 1958, it was decided to form an Australian Mammal Society, for the time being restricted to professional workers actively interested in indigenous Australian species Members of the Society are made aware of the work and material requirements of fellow members and the interchange of material between members is encouraged The inaugural meeting of the Society was held in the Department of Zoology, University of Western Australia The following are the foundation members of the Society J H Calaby, F N Ratcliffe (A. C T), Dr A Bolliger, Dr. R G Chittleborough, Prof K W Cleland, W H Dawbin, Dr A G Lyne, B J G Marlow, E Le G Troughton (New South Wales), A E Newsome (Northern Territory), Dr J L Harrison (Queensland), Phyllis Pilton, G B Sharman (South Australia), C W Brazenor, J McNally, J A Thompson (Victoria), Jennifer M Barker, S Barker, C H Tyndale-Biscoe, E H M Ealey, Dr W D L Ride, Dr J W Shield, G M Storr, Prof H Waring (Western Australia) The secretary-treasurer for 1958–59 is Mr S Barker, Department of Zoology, University of Western Australia

Linnean Society of London : Officers

At the anniversary meeting of the Linnean Society of London the following were elected officers for the session 1959–60 *President*, Prof C F A Pantin, *Treasurer*, the Earl of Cranbrook, *Secretaries*, Dr H R Hewer (zoology), Dr C R Metcalfe (botany), Dr John Smart (editorial) Prof L J Audus, the Earl of Cranbrook, Mr A W Exell, and Dr H G Vevers were appointed vice-presidents Mr E J H Corner, Dr G Owen Evans, Mr C C Hentschel, Dr A Melderis and Mr Wm T Stearn were elected new members of council Linnean Gold Medals were presented to Prof H Munro Fox and Prof Carl Skottsberg Prof Jean G Baer was elected a foreign member and Mr Warren R Dawson an Associate *honoris causa*

Ramsay Memorial Fellowships

The Ramsay Memorial Fellowships Trustees have made the following awards of new fellowships in chemistry for 1959–60 a General Fellowship at the University of Aberdeen to Mr P J T Tait, a Canadian Fellowship to Mr W G Paterson at the University of Oxford, a Japanese Fellowship to Mr Toshinobu Anno at the University of Oxford, a Netherlands Fellowship to Dr H C Volger at the University of London (University College), Spanish Fellowships to Dr Felisa Nuñez Cubero at the University of Nottingham, Mr J B Callija at the University of Bristol, Swiss Fellowships to Dr Otto Stamm at the University of London (Imperial College of Science and Technology), Dr Fritz Kneubuhl at the University of Southampton The Trustees have renewed the General Fellowship to Mr G S Laurence for work at the Atomic Energy Research Establishment at Harwell

City of Paris Medal Awards

At the recent International Conference on Information Processing held at Unesco House, medals of the City of Paris were awarded as follows The Vermeil Medal to Prof Howard H Aiken (United States), Silver Medals to I I Basilewsky for Prof Dimitri Panov (U S S R), Isaac L Auerbach (United States), Maurice V Wilkes (United Kingdom), Adriaan van Wijngaarden (Netherlands), Hideo Yamashita (Japan), Alwin Walther (German Federal Republic), Aldo Ghizzetti (Italy), Stig Comet (Sweden)

Announcements

Sir Hugh Linstead has been appointed a member of the Medical Research Council in the place of the late Mr Richard Foot, M P

Mr Henry Edmunds, county advisory officer for Breconshire, has been appointed assistant agricultural and food attaché in Washington He replaces Mr O G Williams

Dr J H Piddington, of the Commonwealth Scientific and Industrial Research Organization (Australia) Division of Radiophysics, has received the T K Sidey (Summertime) Award, made each year by the Royal Society of New Zealand The Award was given for his theoretical explanation of heating in the atmosphere of the Sun He also received the David Syme Research Prize of the University of Melbourne recently for this work

The following officers of the Institution of Electrical Engineers have been elected *President*, Sir Willis Jackson, *Vice-Presidents*, G S C Lucas, O W Humphreys, *Honorary Treasurer*, E Leete

The Quality Control Group of the Textile Institute will officially come into being on November 10, when a conference on this subject will be held in Harrogate Further information can be obtained from Mr L H C Tippett, British Cotton Industry Research Association, Didsbury, Manchester The inaugural meeting and conference of the Physics Group of the Institute will be held in Buxton on October 8 and 9 Further information can be obtained from Dr H O Pauls, British Nylon Spinners, Ltd, Pontypool

Butterworths Scientific Publications, Ltd, 4–5 Bell Yard, Temple Bar, London, W C 2, announce that a new quarterly journal, *Polymer a Journal to Promote the Science of Large Molecules*, is to appear in October It has been founded to provide an international medium for the publication of original papers on the chemistry, physics and application of polymer research The Advisory Editorial Board consists of Dr C H Bamford, Courtaulds, Ltd, Research Laboratory, Maidenhead, Prof C. E H. Bawn, University of Liverpool, Prof Geoffrey Gee, University of Manchester, and Dr Rowland Hill, research director, I C I Fibres Division, Harrogate

THE WATER POLLUTION RESEARCH LABORATORY

THE Water Pollution Research Laboratory of the Department of Scientific and Industrial Research held open days on May 6 and 7 This organization was formed in 1927, but the Laboratory at Stevenage was not occupied until October 1954 The total staff, which includes chemists, chemical engineers, physicists and biologists, is at present about 120 The Station carries out small-scale and pilot-scale work and also has facilities for work with large plant built in the open, particularly on the treatment of sewage, which can be pumped from a domestic sewer crossing the site It was stated that an additional wing, containing further pilot-scale laboratories, is being designed and that it will probably be built in 1960

The field of work of the Station is in the improvement and development of methods of treating sewage and industrial effluents, and in the study of the effects of pollution on surface waters, including rivers and estuaries Of the work on sewage, part is of an empirical kind and part more fundamental In the first category, for example, the Laboratory is comparing the efficiency of different types and size of medium in percolating filters, of which there is a large experimental installation in the grounds The more fundamental work on sewage includes a detailed study, mostly with pilot plant, of the mechanism and efficiency of aeration in the activated-sludge process, of the factors affecting the drying of sewage sludges, and of the effect of household detergents on sewage treatment Apart from the obvious effects of these materials—that is, the occurrence of foam, often some feet deep, at sewage works—they have caused a marked deterioration in the biological processes of treatment at some works, particularly at those which use the activated-sludge process, in which sewage is aerated either mechanically or by diffused air in contact with an active bacterial floc Work at Stevenage has shown that the immediate effect of detergents is to reduce the rate of transfer of oxygen from bubbles of air to the liquid, and that in those plants where initially the rate of aeration was sufficient only to maintain a comparatively small concentration of oxygen in solution, the further inhibition of oxygen transfer has been responsible for the deterioration observed It was announced recently that manufacturers of detergents were trying to develop surface-active materials which would be more easily decomposed by bacterial action than those at present in use, and in one experimental plant at the Laboratory some of the more promising compounds were being tested by treating them, in admixture with domestic sewage, in small activated-sludge plants In these tests the conditions of operation are controlled , for example, the liquid is aerated with mixtures of air and nitrogen to maintain a desired constant concentration of oxygen in solution Some of the materials submitted for test are much more readily decomposed during sewage treatment than are those at present on the market

A substantial effort is directed to the improvement of methods of treating industrial waste waters, and in this work the Laboratory is closely associated with the Federation of British Industries One investigation now nearing completion has dealt with the anaerobic digestion of certain industrial liquors—for example, those from slaughter-houses—containing high concentrations of organic matter For suitable liquids this process may well be economic—for example, with slaughter-house waste more than 90 per cent of organic carbon is converted to methane and carbon dioxide during a period of treatment of 24 hr —and the process is likely to go into full-scale use in Britain in the near future A plant was also shown in which tannery wastes, which often contain sodium sulphide used for removing hair from hides, is treated with flue gas to neutralize it, the hydrogen sulphide in the flue gas being oxidized to sulphuric acid by biological action in a percolating filter Apart from these long-term projects the Laboratory acts as an advisory service to industry and frequently undertakes short investigations for particular firms on a repayment basis

One important aspect of the work of the Laboratory is the study of the effects of polluting substances in surface waters For some years the chief object of this study has been the Thames Estuary, the central reaches of which in dry weather are anaerobic, and where in consequence sulphate is reduced to sulphide by bacterial action This survey, the final report on which has not yet been published but is in preparation, has involved much experimental work—for example, determinations of rates of oxidation of organic materials at different temperatures, and the study of the conditions in which ammonia is oxidized or nitrate is reduced by bacterial action—the results of which are applicable to the far simpler system of a fresh-water stream In the Thames Estuary the most important effect of pollution of all kinds is to reduce the concentration of oxygen in solution in the water, since it is only when this has fallen to zero (and when any nitrate present has been reduced to nitrogen) that evolution of hydrogen sulphide occurs In fresh-water streams many other effects of polluting substances may be important, particularly if the stream is expected to support a fishery or if the water is used for a public supply, but the lowering of the concentration of dissolved oxygen which results from the discharge of any oxidizable material is still one of the most objectionable results of pollution, and the level of oxygen is often taken as diagnostic of the general quality of the water

In rivers which contain fish, oxygen tension is particularly important, not only because a certain minimum level is necessary to support fish life, but also because a reduction in tension increases the toxicity of any poisons which may be present The Laboratory is studying the various factors which govern the oxygen balance of streams, in the hope of being able to reduce the margin of error with which the oxygen profile below the point of discharge of a given effluent to a given river can be predicted, and has already made some progress in this direction The work has been greatly facilitated by the development of a robust recorder of the dropping-mercury type which can be used to give a continuous record of the level of dissolved oxygen in a river The programme involves a knowledge of the rate of oxidation of polluting substances, of the rate at which the water of a stream will absorb oxygen from the air, and of the effects of aquatic plants and animals on the oxygen balance

In the field, the only satisfactory method at present available for determining the rate of transfer of oxygen from the air is to reduce the oxygen tension in the water (by adding sulphite and a catalyst), following then the rise in level of oxygen below this point This method has been used successfully for small streams, but presents obvious difficulties in a large river Many of the factors involved, however—for example, turbulence, and the presence of substances such as detergents in solution which reduce the rate of oxygen transfer—are being investigated by running water through sloping troughs, 100 ft long, in the grounds of the Laboratory One question which is often important in Britain—namely, the change in oxygen-level in water when it flows over weirs—has been substantially settled by work in the field and in pilot-scale plant, given the height from which the water falls, and the temperature, the extent to which the oxygen deficit is reduced can be predicted within narrow limits

In rivers, oxidation and reduction of compounds of nitrogen often play an important part Oxidation of ammonia and reduction of nitrate, and particularly the effect of concentration of dissolved oxygen on these processes, are being studied in an artificial river in which water passes through a series of tanks fitted with stirrers In streams containing large numbers of algae or much rooted vegetation, the effects of the bacterial oxidation of polluting matter on oxygen tension may be greatly outweighed by photosynthetic production of oxygen and its consumption by plant respiration These effects are being studied in a stream near the Laboratory, where continuous recorders are installed In June and September 1958 there was a net release of 3 8 gm oxygen/m ^{2}/ day Estimates are being made of the productivity of different reaches in this stream using cropping techniques assisted by aerial photographs taken by a camera suspended from a meteorological balloon Consumption of oxygen by respiration of invertebrates is also significant, and this is being determined in respirometers in which the change in oxygen tension is again recorded continuously.

The Laboratory has a small but well-equipped Microbiological Section in which three main lines of work are in progress The first is a detailed study of the changes which occur when aqueous solutions of organic compounds (which may be radioactively labelled) are passed over an active microbial film of the type which occurs in percolating filters and on which the purification of sewage by this process depends The film is built up on the inside of a 'Perspex' cylinder, the long axis of which is inclined and about which it is rotated, the atmosphere in contact with the film is circulated and there are arrangements for withdrawing samples from it and for adding oxygen to replace that used in oxidation Most of the organic substances present in such materials as sewage are very rapidly oxidized ; one object of the work is to identify those which are not

It is very important, in treating polluting liquids by biological processes, to be able, in the last stage of the process, to remove by sedimentation organic sludge from the liquid—the latter representing, of course, the final effluent from the plant A large part of the organic matter to be removed consists of bacteria and the quality of the final effluent depends very largely on whether they will or will not agglutinate in the final sedimentation tank In spite of a good deal of work on the subject, not much is known of the factors which affect flocculation in a treatment plant, these are therefore being studied by the section, using cultures isolated from sewage and sewage effluents

The third line of work which is being pursued in collaboration with the National Coal Board is on the bacterial treatment of waste waters from coke ovens, in which the chief constituents to be removed are phenols, thiocyanate and ammonia Rates of assimilation and oxidation of these substances are being studied in continuous-culture apparatus after preliminary trials by the usual Warburg technique

The Microbiological Section has recently been strengthened by the transfer to it of some of the staff formerly working at the National Chemical Laboratory

WATER SUPPLY AND DEMAND IN GREAT BRITAIN

THE problem of water supply and demand, the need for improved hydrological knowledge and the necessity for a continuing study of the changing situation in Britain, have received editorial notice in earlier issues of *Nature* (172, 823, 1953, and 176, 1133, 1955) The decision to suspend the Inland Water Survey and disband the Central Advisory Water Committee during the economy measures of 1952 was, from a purely scientific point of view, strongly criticized Happily this decision was reversed in 1955 when the Central Advisory Water Committee was reconstituted, and in the same year the Inland Water Survey also recommenced its labours and has since published a great deal of information covering the post-war years

One of the first actions taken by the Central Advisory Water Committee in 1955 was to appoint two subcommittees to investigate information on water resources and the growing demand for water Both these subcommittees have recently reported to the Central Committee and the information collected so far has now been published*

Of the two documents, that of the Subcommittee on Information on Water Resources is perhaps the least controversial and may be considered first This Subcommittee was appointed with the following terms of reference (i) to review the current activities which contribute to our knowledge of the nation's water resources, (ii) to define the additional work needed to make a balanced survey of the quantity and quality of surface and underground water available for domestic, industrial and agricultural use, (iii) to advise on ways of collecting and interpreting the necessary information, correlating it with information from other sources and publishing it

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* Central Advisory Water Committee Subcommittee on The Growing Demand for Water—First Report Pp iv+28 1*s* 3*d* net Report of the Subcommittee on Information on Water Resources Pp ii+20 1*s* 3*d* net (London H M Stationery Office, 1959)

The review of current activities deals with the work of the Meteorological Office (Air Ministry), the Surface Water Survey Centre (Ministry of Housing and Local Government) and the Geological Survey in providing information on rainfall, evaporation, surface water and ground water It is recommended that the Geological Survey should resume publication of information on ground water , and that all data on rainfall, surface water and ground water should be presented on a common basis of river basin areas The planned future contents of "British Rainfall" and the "Surface Water Year Book" are endorsed, and the proposed arrangements for the collection and interpretation of hydrological information are considered adequate to meet the known need, although certain extensions of existing activities are recommended The more frequent inspection of rainfall stations, the more accurate recording of snowfall, additional recording of ground water, the publication of more data on the quality of certain water supplies and the more rapid completion of the network of river gauging stations are all considered desirable

Although the arrangements for the collection and interpretation of information are considered "broadly [to] meet the known need", the report recognizes the necessity for additional investigation into hydrological relationships and for further inquiry into the use of hydrological information It is therefore also recommended that work at present being done on hydrological research should be reviewed to determine how such work should be co-ordinated and what extensions or modifications may be desirable The lack of any central hydrological information and research organization comparable to the Geological Survey or Meteorological Office has already been noted elsewhere*. The publication of this report on information on water resources really arises from the lack of such a body, since data on the hydrological cycle in Great Britain are scattered among such a variety of authorities each of these authorities is only interested in one aspect of the complete cycle The recommendation that all hydrological results should be presented on a common basis of hydrometric areas is, however, a significant move towards a closer integration of the available data

The report of the Subcommittee on the Growing Demand for Water is a longer document, although despite three years deliberation and investigation it has appeared as a first and not as a final report, for the subcommittee found its terms of reference more exacting than anticipated These were "To consider the extent to which the demand for water for domestic, industrial, agricultural and other purposes is increasing and is likely to increase, to consider the problems involved in meeting these demands, including, in broad terms, the cost , to consider whether there are any substantial economies in the use or cost of water which could be made without reduction in standards of hygiene or in industrial or agricultural efficiency , and to make recommendations"

The main questions which remain unanswered concern the demand for water for agricultural irrigation and economies in the use of water in industry The chief difficulty experienced in the investigation was related to the dual character of water supply in Great Britain which is provided by both public water undertakers and obtained privately and the threefold nature of the demand, which is domestic, industrial and agricultural Accurate statistical information on consumption is readily available only from the public water undertakers, but even here the amounts in the various categories of use are not fully known The subcommittee instituted its own official inquiry among all public water undertakers, the nationalized industries (electricity, coal, gas and transport), and six major industries (brewing, chemicals, iron and steel, leather, paper and textiles) where supplies are largely obtained privately A large and valuable collection of new statistical data has therefore been accumulated , and this, together with the unpublished water surveys carried out between 1945 and 1958 by engineers of the Ministry of Housing and Local Government, form the basis of the recommendations accompanying the report

In the industrial and domestic categories there is clear evidence of a steady nation-wide increase in water consumption of between 2 and 3 per cent per annum during the past quarter of a century This is expected to continue into the future to produce by 1965 something of the order of a 25 per cent increase over the known 1955 consumption figures As new works under construction, or proposed, are scheduled to yield an additional 800 million gallons of water a day by 1965, and this is approximately 40 per cent of the quantity distributed by water undertakers in 1955, the subcommittee concludes that in England and Wales as a whole the rising consumption need not give rise to immediate anxiety This general statement is, however, immediately qualified with the proviso that "this is not to say that temporary or local shortages will not recur from time to time, quite apart from more general shortages in very dry years (when maximum domestic demand and minimum supply tend to coincide), or that industries seeking new sites will find abundant supplies in any place they care to choose" The estimates also assume that in any particular area the trend of consumption will follow approximately its present course, so that any significant deviation not foreseen at present could upset the balance

Beyond 1965 the Subcommittee was "unable to obtain any reliable data" and decided not to attempt numerical estimates The subcommittee is therefore not prepared to commit itself other than to express the opinion that there need be no shortage of water in any part of England and Wales provided that development schemes are prepared well in advance of demand, that the necessary statutory powers and other authorizations are granted, that capital investment is permitted on the requisite scale and the location of industries which require large quantities of water is regulated with the water supply situation in mind

While acknowledging the great amount of work which has clearly gone into the inquiry, and the valuable new information which the report presents, it must be admitted that there are a number of debatable points In the first instance the Subcommittee has based its arguments upon figures of past consumption which are not necessarily indicative of past demand, and could certainly be misleading so far as future demand is concerned This is most evident in the agricultural usage of water Quite apart from the fact that the consumption rises rapidly as soon as piped water becomes available to a farm, there is the whole unresolved and rapidly growing problem of agricultural irrigation The work done at Rothamsted Experimental Station shows, for agriculture, a deficiency of rain in more than five years out of ten south of a line drawn from the Humber to the Severn, and a deficiency in nine years out of ten in Essex, Suffolk and Kent The magnitude of the deficiency varies from place to place and from year to year with theoretical values ranging from 1 in to 12 in of rain The irrigation that would be needed to meet this deficiency would depend on soil moisture retention conditions and plant rooting characteristics, and might amount to a rainfall equivalent in some places of up to 6 in All the water would be used in transpiration or evaporation, or absorbed by percolation, and would not be capable of re-use Calculations indicate that a possible demand of some 8,000 million gallons a day might exist in very dry years south of the Humber–Severn line This amount is more than four times that supplied in 1955 by all the public water undertakers in England and Wales, and it indicates the potential demand which exists and which the subcommittee has ignored in its first report It is proposed, however, to give further attention to this problem, but the approach appears to be negative as the possibility is mentioned of some form of control over the abstraction of surface water analogous to the existing protection of underground water If the national policy is to secure the maximum food output from the agricultural industry, farmers in south-east England should be actively encouraged rather than discouraged to irrigate, in which case a more positive approach to the water supply problem and a completely different attitude of mind are then needed

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* Balchin, W G V , *Water and Water Eng* , 61, No 734 (1957)

The reluctance of the Subcommittee to look further ahead than 1965 is also unfortunate, although the difficulties can be fully appreciated The Ministry of Health Committee on Causes of Increase in Consumption of Water (1949) was prepared to look ahead for a period of some 22 years up to 1970 Past experience clearly shows that water-supply schemes take many years to come into operation and that reliability in supply largely depends on one generation planning for the next The blue prints to meet the requirements of the late 1970's should be in process of formulation in the early 1960's if the real needs of agriculture and industry are to be satisfied

Possible economies in the use of water in industry have also been deferred for future consideration, although the report does direct attention to waste prevention and leak detection , the recommendation is made that all water undertakers should operate an adequate waste prevention service

There is clearly much food for thought in both of these reports The rising standard of living of an increasing population in Great Britain has, in the present century, brought water to the forefront as a vital and essential commodity in the life of the nation Although the natural resources of the country in terms of rainfall are theoretically adequate, Nature has a habit of distributing the precipitation unevenly in both time and place This situation can only be remedied by care in use and by the conservation of supplies in periods and areas of plenty Lowland Britain, where consumption is greatest, is also the area where the population is densest, the rainfall least and where local water resources are nearing full utilization Highland Britain, on the other hand, has a low population, the highest rainfall and a relative over-abundance of water of which only a small proportion has yet been developed To what extent would the gains from scientific irrigation in agriculture and a guaranteed domestic and industrial supply in lowland Britain outweigh the cost of storage and movement of water from highland Britain ? And how far might the conversion of saline water in Great Britain assist in the solution of the water-supply problem ? It seems that these are the major questions on water supply that must be answered if the problem is to be approached with vision and concern for the needs of the next generation

W G V BALCHIN

TEN YEARS OF ERGONOMICS

ERGONOMICS is mainly about 'human factors' in the design and operation of machines, and about the physical environments in which men use their machines Moreover, it is multidisciplinary Nobody who attended the tenth anniversary meeting of the Ergonomics Research Society, held in Oxford during April 6–9, could have much doubt on either of these points

The Postmaster-General, Mr Ernest Marples, apparently less damaged than he should have been by a 400-mile cycling trip in France on what seems to have been a highly unergonomic saddle, opened the conference He had hard things to say about the word 'ergonomics' Unlike his chairman, the Master of Balliol, who thought it was splendid because it told us exactly what it meant, Mr Marples thought it was frightful because it did not However, for ergonomics itself he had nothing but praise The General Post Office had used it for nine years , and it was his intention to build it into the General Post Office structure so firmly that it could be got out again only by 'positive action' He pledged his support for everyone, everywhere, including housewives in their kitchens, who moved ergonomically with the times

Following up a point Mr Marples made about the frequency with which "backroom boys" are either not understood or misunderstood, Sir Frederic Bartlett, formerly—for twenty-one years—professor of experimental psychology in the University of Cambridge, inquired how common difficulties of communication might be overcome, so that proved advances (for example, in the design of altimeters) might be adopted with reasonable rapidity Mr Marples advised him to get into touch with the top people concerned, or with the Parliamentary and Scientific Committee, or with Mr Marples himself Sir Frederic looked rather less happy about this than did Mr Marples

There was more to come from the General Post Office A paper by Dr R Conrad, of the Medical Research Council Applied Psychology Unit at Cambridge, dealt with mass communication systems , and a couple by Dr W F Floyd, of the Middlesex Hospital Medical School, and Miss June I Jones, of the General Post Office, covered some problems of lighting, posture, thermal conditions and energy cost of work in telephone exchanges and Post Office factories These gave a clear indication of what ergonomics amounted to in practice Dr Conrad told us that to obtain a weather report he had to dial 96618312274 As this kind of thing was spreading, it had been decided that some General Post Office-based studies of immediate memory might pay off One proved useful in comparing conventional dials with push-button arrangements, and another helped in working out the kinds of codes that might be suitable for trunk numbers or postal addresses Dr Conrad's concern with efficiency was matched by the interest Dr Floyd and Miss Jones displayed in comfort, but Dr Conrad led the other two in his theorizing

These three early speakers did, in fact, throw up, without explicit formulation of them, problems which were to rear their heads frequently during the conference What had Dr Conrad in common with Dr Floyd and Miss Jones apart from the General Post Office roof over his head ? All he said—and, indeed, all his director, Mr D E Broadbent, said in a later paper—could easily have been labelled 'applied experimental psychology', and all that Dr Floyd and Miss Jones said is usually called 'applied physiology' Where does ergonomics come in ? Does it seek to be regarded as a new science ? If so, on what is its claim to independent scientific status founded ? Has it any distinctive concepts or methods ? Is it, perhaps, mainly a convenient gathering-place for people belonging to certain technological wings of certain human sciences, and their agents and users in industry ?

As if these puzzles were not enough for us, more were produced by delegates who came from the work-study sector of industry One, Mr A Graham, of Imperial Chemical Industries, created a small squall after some plain speaking by Mr H Murrell, the founder of the Society Mr Graham asked scornfully why industry should be expected to prefer the 'toothpick' of ergonomics to the 'pneumatic drill' of work-study; and having delivered himself of this broadside, he switched on his own pneumatic drill and demanded that work-study practitioners should be offered both help and respect He gave the impression that what was really worrying him was the intrusion of still more outside 'experts' At this point Mr A T Welford, the editor of *Ergonomics*, deftly applied the oil-can However, it seems that later in the day, at the Society's annual general meeting, Dr E A Muller, of Dortmund, set the cat among the pigeons again by suggesting that meetings between research workers and people from industry were a doubtful blessing and should be only occasional

It may appear, from all this, that the conference was a bit of a mix-up So indeed it was But it was probably a healthy one The physiologists and psychologists, though going their separate and unintegrated ways, somehow did battle together with the delegates from industry True, each side paid tribute to the other and to some extent shared a common cause, but the sparks flew Perhaps even more would have flown if the meeting had been held in less academic surroundings The industrial contingent were inclined to be a little shy

The nature and quality of the papers were as mixed as the audience Though the title given to the conference as a whole was "Symposium on Ergonomics, its Place in Industry (Past Progress and Future Trends)", only a few of the contributions played up to it These came mostly at the beginning, from Mr Welford and from Dr O G Edholm, of the Medical Research Council Division of Human Physiology, and at the end, from Mr Broadbent, from Dr E H Christensen, of Stockholm, and from Mr L V Green, of Dunlops The rest were chiefly individual papers Among them were a description of work done on design problems in E M I Electronics, given by Mr B Shackel, and an account of activities in the Clothing and Stores Experimental Establishment of the Ministry of Supply, given by Dr E T Renbourn and Mr H C Stockbridge Mr C E Brooks, of Personnel Administration, Ltd, had some sensible things to say about improving the quality and output of inspectors by systematic re-training, but the information he produced in support of his findings did not carry conviction to everyone; nor did it seem to have much to do with ergonomics

Despite this bittiness, a good deal of stimulation was provided Mr Murrell's own contribution, mentioned earlier, was not what he meant it to be, because a midnight argument had made him decide to scrap the original In the event it turned out to be a usefully provocative statement about what 'ergonomists' could do for industry that methods engineers could not They could bring to their task knowledge of the capacities and limitations of human beings not to be found in the publications of Shaw, Mundel or Barnes More than that, they could bring to it skill in the conduct of experiments with 'chaps' A methods engineer plus a psychologist or half a physiologist would produce a different outlook on industrial problems This was the straight-from-the-shoulder stuff that caused offence to Mr Graham To some others it caused perplexity, for it left unclear the distinguishing characteristics of the ergonomist, the psychologist, and the physiologist A few among the faithful were dismayed, because although they talk about ergonomics, they do not like the label 'ergonomist'

In a comment on a paper by his E M I Electronics colleague, Mr J R Arrowsmith, Mr Shackel had a good point to make about the function of machines in relieving the anxieties of skilled men who build up great tension as the possibility of spoiling several days work mounts So had Mr Broadbent, in the same discussion, when he remarked that in our hopes for the elimination of human error, through the taping of instructions, we must not neglect the risk that the typist typing the tape may err Earlier, Mr W D Seymour had asked, rather drily, how many of the matters discussed at the conference had not been investigated by industrial psychologists twenty-five years ago

So some extent, Mr Seymour's question was answered in a later contribution by the present writer, who made comparisons between the first ten years of ergonomics and the first ten years of occupational psychology The chief differences seemed to lie in the wider scope of occupational psychology It encompassed problems of 'fitting the man to the job' as well as problems of 'fitting the job to the man', and it studied attitudes as well as skills Dangers arising from narrowing the range of the industrial problems taken into account were illustrated by Dr J J O'Dwyer, of Unilever, who spoke about informal groups in industry, and the importance of perceiving and using them, and by Mr R M McKenzie, of the Social Sciences Research Centre at Edinburgh, who showed—entertainingly—how social factors could keep a worker's output well below his potential

What of the next ten years ? If the members of council of the Ergonomics Research Society have not yet drawn their conclusions from their experience of the first decade, they might think about covering the following points in their discussions First, there is perhaps little to be gained by making ergonomics out to be a science It is a kind of conglomeration—not even a compound—of technologies, and it might be a good thing for it to continue like that Possibly the Society should be content to serve the same kind of admirable purpose as the British Nuclear Energy Conference, which pulls in people from a number of fields without seeking to detach any of them from their primary allegiances

Secondly, there is undoubtedly a lot to be said for the running of courses of lectures and practical work for people, from a variety of levels and types of work who are faced with 'ergonomic' problems The short Bristol course outlined by Dr S Griew seems sound in its aim, which is to put across useful facts about the structure and functioning of the human body, to show where more can be found, to explain and demonstrate experimental approaches to problems of equipment design, and to suggest that 'fitting the man to the job' and 'fitting the job to the man' should often be tackled together

Thirdly, however, there is perhaps room for far more stress on the need to look into, learn about and teach people about, individual differences, especially on the psychological side Mr Stockbridge's *cri-de-coeur* ("Individual differences are a frantic nuisance If only we had a standard man ") brought out this need Some workers in this field are clearly tempted, not merely to wish that there were such a creature, but to assume that there is Mr Welford seemed almost to succumb when he spoke hopefully about the discovery of 'standard times' for mental operations, and more particularly when he hinted that one had been run to earth in Antwerp, where telephonists had consistently coped with five bits of information a second Dr Conrad, commenting on this later, unwittingly challenged Mr Welford by revealing that Norwich girls could manage seven without any trouble

Discrepancies like this cannot really be met by jocular references to the possible existence of 'national' differences They must be taken seriously Could they arise from differences in the kinds of people being guided into and selected for the work in different places or at different times? Or from differences in training arrangements? Or from differences in methods of work adopted? Or from differences in equipment? Or from differences in working conditions of several kinds, including the physical, the social and the financial? All these and other possibilities should be explored

But here we encounter two important snags Can exploration of the kind needed be carried out satisfactorily on the tiny, homogeneous, doubtfully relevant groups often used by researchers in the vast field of ergonomics? And can it be tackled adequately by researchers whose devotion to 'precise' measurement is such that they are inclined either to forget or to ignore deliberately the existence of possibly influential factors which lie beyond the reach of their cherished clocks and counters? The state of play in ergonomics ten years from now may depend a good deal on the answers the Council of the Ergonomics Research Society gives to these two questions

Alec Rodger

DISTRIBUTION OF SCIENTIFIC PUBLICATIONS IN UNDER-DEVELOPED COUNTRIES

THE Scientific Publications Council, which has recently been formed, includes the editors of twenty scientific journals and the authors of a number of scientific books It was started by a group of scientists who felt the need for an independent body that could uphold the interests of scientific authors and editors in working for higher standards in the publication and distribution of scientific books and journals The Council is intended to provide a means for scientific writers and editors to maintain contact with each other and exchange views with others concerned in scientific publication in Great Britain and overseas it provides a forum for the discussion of matters of mutual interest and a means of obtaining advice in technical and legal matters relating to publication It is intended that the Council should work to establish good relations between scientific writers and publishers, and co-operate in setting up agreed standards that are acceptable to scientists and publishers alike The officers of the Council are appointed for a term of three years, Prof G W Harris is chairman of the Council and Dr D Richter, Neuropsychiatric Research Unit, Whitchurch Hospital, Cardiff, is honorary secretary

At a meeting of the Scientific Publications Council held on April 10 at the Ciba Foundation, London, Mr John Hampden (British Council) opened a discussion on the distributions of scientific publications in the under-developed countries He described the difficulties experienced in many countries in obtaining British books and periodicals In Asia and Africa there is rapidly growing up a new literate class which wants to read, but in many places no British publications are available In some places it is hard to persuade any bookseller to obtain them, as the necessary currency authorization is difficult, expensive or impossible to get, and the profit is small On the other hand, there is an abundant supply of State-subsidized cheap editions from the U S S R, China and also the United States The English language is now an international possession The students wanting books are the scientists, professional men and leaders of the future, and it is bound to affect their future reading and outlook if the only books they can get are not British

Currency shortages are mainly responsible for the situation in some countries, including Poland, Turkey, Israel, Pakistan and Indonesia How can people in these countries buy British books and periodicals if they have no sterling to pay for them? Other difficulties in some countries include the shortage of bookshops stocking British books and the lack of libraries where British publications can be seen The difficulty is especially acute for scientific and medical books, which are needed by specialists In the Western countries where libraries are largely taken for granted, it is hard to realize that in many places a student may have access to very few books which he does not buy for himself, and the cost of one book may be more than a whole month's salary In many places it is even impossible to get up-to-date lists of British books and their very existence is in danger of being forgotten

The Americans have got round the currency restrictions by export schemes in which the publishers are paid directly by the Government, so that the importing countries need no dollars to pay for books This was originally a British idea (invented by Sir Stanley Unwin) which the Americans have adopted British text-books have been deservedly popular in Asia and Africa for many years, but there is a serious danger that they will soon be swept out of some important markets Mr Hampden said we are not afraid of fair competition, but British publications cannot compete with exports heavily subsidized by foreign governments It is a matter of considerable concern to those familiar with the situation that the journals of many British learned societies are not organized as the book-publishers are to increase their sales overseas, and it looks as though these journals are getting seriously left behind It is essential that more information about British scientific books and journals should be made available overseas The British Council is doing all it can to spread this information abroad

Dr P Rosbaud said that the cultural importance of scientific books has only recently been appreciated in Great Britain The export of scientific and technical books is not only of benefit to the book trade but also has a far-reaching influence on education and commerce in general, so that it pays high political dividends as well One of the main factors influencing distribution abroad is the cost Why are scientific books so expensive in comparison with other books of similar size, and where do all the profits go ? For a typical book of 250 pages selling at 30*s* the publisher may hope to sell 3,000 copies and break even at 2,400—if he sold less than 2,400 he loses , if more, he gains For such a book the printer's estimate may be 8*s* a copy, including the cost of correction, blocks and paper There is little to be saved by using paper of cheaper quality The publisher's overheads might be 2*s* 6*d* , advertising 2*s* and the author's royalty at 12½ per cent would be 3*s* 9*d* Allowing 33 per cent, or 10*s* for the bookseller, that left the publisher with only 3*s* 9*d* as his profit In any sales in the United States the publisher may need the services of an American distributor who would ask 50–60 per cent of the selling price, and the British publisher would also have to pay the additional cost of freight There is the alternative of selling a small number of books at a high price or a larger number at a lower price, as with text-books Text-books have got to be cheap, and this might be achieved by bringing out a large first issue of 5,000 copies without profit and then making a profit on subsequent issues It was not right that the author should ever be asked to waive his royalty, which was little enough anyway no reputable publisher would ever ask that In the publication of scientific journals great patience might be needed before a profit could be made Sir Richard Gregory had told Dr P Rosbaud that *Nature* took more than twenty years before the circulation was sufficient for it to make its first profit Publishing a journal is like cultivating a garden in which one must wait a long time for the harvest As the circulation increases and the journal gradually becomes more profitable, the publisher can pass some of this on to the consumer by reducing the price or increasing the size Scientific journals could be made considerably cheaper by including advertising space Otherwise, the only way of reducing the cost is to increase the circulation Where publishing is a government monopoly, as in the U S S R , books and journals can be produced at a very low cost , but there are objections to this practice Such publications may have plenty of room for the Lysenkos, but not for the Vavilovs and Pasternaks, and the results are tragic There is an urgent need for the British Government to develop an effective export scheme in answer to the floods of cheap State-subsidized publications from other countries

The chairman, Prof G W Harris, asked how scientists in Britain could best help in getting scientific books and journals distributed in the countries that need them Mr Hampden thought that the Scientific Publications Council might help in bringing the problem to the notice of the learned societies Dr F. N L Poynter described the work of the Wellcome Historical Medical Library in collecting scientific books and medical journals and distributing them in under-developed countries abroad He thought it would be helpful if the existence of a voluntary distributing centre of this kind were made more widely known

MAPPING VEGETATION

AN international symposium on mapping vegetation was held during March 23–26 in Stolzenau/Weser, in the Federal Republic of Germany This gathering of 112 scientists from sixteen countries, including Japan and the United States of America, was organized by the head of the Bundesanstalt fur Vegetationskartierung, Prof R Tuxen (Stolzenau), on behalf of the International Society for Plant Geography and Ecology

The rapid progress of phytosociology (phytocenology) in this century, especially during the past three decades, has made feasible the scientific mapping of vegetation based upon well-defined plant communities In view of recent advancements in this field, an international meeting to facilitate exchange of views, personal contacts and assessment of new future developments was very timely

Mapping of vegetation at the Bundesanstalt fur Vegetationskartierung (formerly Zentralstelle fur Vegetationskartierung des Reiches) began in 1931 for the Nature Conservancy Service in Hanover Then, as now, the mapping of vegetation was preceded by extensive field work on existing plant communities in the respective area by the methods of the Zurich–Montpellier school of phytosociology In addition to fundamental research on plant communities, their ecology and distribution, a large variety of applied research programmes have been completed which involved mapping actual and potential vegetation for various practical aims in agriculture, forestry, water supply, transport and nature conservancy At present, a large programme of vegetation mapping has been undertaken for the West Germany railways, in which the vegetation along about 30,000 km of its railway network will be mapped to provide a sound basis for certain practical measures For some time the Institute has been working on a complex research problem concerning the relationship of a particular plant community to the soil profile, and members of the symposium were much impressed by the exhibition of about 300 large, well-prepared soil profile mounts from north-west Germany In solving many complex problems on vegetation for Germany, this independent research institute has become indispensable to other neighbouring countries in Europe, which face similar problems of a fundamental or applied nature It is hoped that recent progress will be maintained and its sound future development preserved

The papers presented at the conference may be subdivided into three major groups (*a*) methods, (*b*) recent advances, and (*c*) applications

(*a*) *Methods* The importance of fundamental principles, methods and aims is of much concern in any mapping of vegetation In his introduction, Prof M Schwickerath (Aachen) referred to the significance of 'association diagrams' in mapping, by illustrating this with examples of the *Violon calaminariae* and *Sphagnum* associations Prof A W Kuchler (Kansas) explained the compilation of a small-scale vegetation map of the United States and the various problems involved Prof A Scamoni (Eberswalde) presented the new vegetation map of the East German Republic on a scale of 1 1,000,000 and indicated the principles applied in this work Prof I Horvat (Zagreb) referred to the basic considerations in applying higher units of vegetation while outlining the main features of vegetation in Yugoslavia Prof A Noirfalise (Brussels) reviewed the aims and methods used in mapping the vegetation of Belgium, and those for recording marine biocenoses of the sea bottom off the coasts of France were outlined by Dr R Molinier (Marseilles) On this topic Dr Molinier gave a lecture illustrated by excellent colour slides of underwater scenes taken on various trips in the Mediterranean Prof H Gaussen (Toulouse) explained the choice of colours in cartography, illustrated by his excellent bioclimatic maps of Africa and South America The following five papers from the Bundesanstalt fur Vegetationskartierung dealt with the main principles, methods and techniques adopted there Dr W Trautmann discussed his field experiences, and Dr W Lohmeyer assessed the value of aerophotography Prof R Tuxen stressed the importance of mapping potential vegetation, which is more advantageous in forestry than the actual vegetation Dr K Walter spoke on introductory courses in phytosociology held in Stolzenau, and Dr A Wenzel explained techniques in cartography employed there

(*b*) *Recent advances* The advances made in recent years in phytosociology in various countries and the value of vegetation maps in related fields of science constituted the second topic of the symposium Dr A E Apinis (Nottingham) stressed the relationships of soil micro-organisms to higher plants and the value of vegetation maps for the fundamental research in soil microbiology Prof F Major (Davis, California) outlined the basic approach to vegetation necessary for their mapping on a scale of 2 in to 1 mile, while Mr A. Miyawaki (Yokohama) dealt with the occurrence in Japan of snow-patch communities similar to those of the European mountains Mr S Bertovic (Zagreb) described vegetation mapping in Croatia and in other parts of Yugoslavia, while Dr A O Horvat (Pecs, Hungary) presented a detailed map of forest phytocenoses of the Mecsek Mountains in southern Hungary, and Dr R Neuhausel (Brno) spoke on mapping natural vegetation in Moravia Mr I S Zonneveld (Sleeuwijk, Holland) explained the mapping of both alluvial soils and vegetation in the tidal fresh-water area of the Rhine delta, combining the direct field method with that of aerial photography Mr Doing Kraft (Wageningen) is using physiognomic characteristics in recording the unstable dune vegetation near Harlem Dr J Tuxen (Stolzenau) spoke of the application of vegetation maps in solving problems in the historical investigation of rural landscape, while Prof J Schmithusen (Karlsruhe) emphasized the significance of vegetation maps of various scales in phytogeography and other related sciences.

(*c*) *Applications* The variety of purposes to which the mapping of vegetation may be applied was revealed by the following papers, which were illustrated by a number of excellent large-scale maps Prof A Matuszkiewicz (Warsaw) spoke of developments in phytosociological mapping in Poland and its present applications The possibilities of ecological and phytosociological mapping for applied purposes was discussed by Dr G Long (Montpellier) Prof P Fukarek (Sarajevo) outlined the application of vegetation maps in the forestry work of Bosnia and Herzogowina, and Prof M Wraber (Ljubljana) explained the use of the general map on a scale of 1 100,000 of potential natural vegetation of north-west Yugoslavia as a basis for re-afforestation work on the degraded Karst and Flysh areas The paper of Mr K Mraz and Mr V Samek (Prague) on certain problems on the cartography of vegetation and its applications in forestry was read by Prof R Tuxen

The mapping of vegetation is regarded as the best approach to solving problems of water relations in various plant communities On this aspect Prof H Wagner (Vienna) reviewed the mapping of vegetation for certain purposes in connexion with hydroelectric works in Austria, while Dr K Meisel (Stolzenau) spoke on its importance for the assessment of damage to vegetation due to water Dr P Seibert (Munich) showed the application of phytosociological mapping of 'Pupplinger Au' near Munich to the water economy service there, and an assessment of damage due to salt water to meadows of the Werra Valley was given and its prevention planned on the basis of a vegetation map described by Dr B Speidel (Bad Hersfeld) According to Mr Th A de Boer (Wageningen) mapping of various grasslands in Holland has been combined with soil mapping to provide an efficient agricultural advisory service in certain areas Prof L Steubing (Giessen) found the regular occurrence of certain grassland communities in areas where wind-break hedges are common The importance and practice of mapping Alpine grasslands in Oberengadin was demonstrated by Dr F Marschall (Zurich) The two last papers dealt with certain aspects of nature conservancy Dr E Preising (Hanover) reviewed mapping of vegetation in relation to problems of nature conservancy and landscape, and Mr P Tideman (Doorwerth, Holland) found direct mapping combined with aerial photography very useful in the management of the various protected areas in Holland

Two decisions of general interest may be briefly mentioned (1) A permanent commission was formed for the preparation of a vegetation map of Europe, with Prof R Tuxen (Stolzenau) as chairman and the following members Prof J Braun-Blanquet (Montpellier), Prof L Emberger (Montpellier), Prof I Horvat (Zagreb), Prof A Noirfalise (Brussels) and Prof B Pawlowski (Cracow) (2) The following resolution was adopted for submission to Unesco and all the member Governments concerned "The vegetation of the Earth represents the vital productive potential upon which all life depends Therefore, the comprehensive study of vegetation is of the utmost importance, and for this purpose the combination of ecological, phytosociological and cartographical methods are required

"The present-day methods of mapping vegetation greatly enlarge our fundamental knowledge of plant communities, their development and distribution as well as providing a deep insight into their environments In applied phytosociology the mapping of vegetation constitutes a solid basis for assessment of habitats, for utilization of vegetation, and for the evaluation, or even the forecasting, of any change or damage to vegetation by erosion, wind, water and other natural or human factors

"It is suggested that no large-scale technical measures should be planned or carried out which may influence the vegetation or landscape without first mapping the vegetation prior to the respective technical measures being put into effect "

A E Apinis

BIOLOGICAL FIBRES

It is some time since the X-ray Analysis Group of the Institute of Physics has met to consider biological fibres, so that the conference in Leeds held during April 17–18, even if only partly devoted to fibres, was very welcome It is, however, symptomatic of the present place of specialist techniques (even if they are as well established as X-ray diffraction) in such fields as the study of fibre structure, and perhaps even more of the trend of development of the corresponding specialist groups, that of the seven papers presented on this occasion only two could be classed as predominantly crystallographic in content, whereas in two others, which dealt respectively with infra-red absorption and the electron microscope, X-rays had no more than a casual mention That these other techniques are now essential partners with X-ray diffraction in research on fibre structure was emphasized by the part they played in the other three papers Nevertheless, in this account attention will be confined chiefly to topics which are more closely associated with the nominal activities of the Group

The successful study of the cellulose fibre by X-ray analysis set a fashion which is evidently, even after more than thirty years, not yet outmoded This fibre is still presenting fundamental crystallographic problems for investigation, for example, it seems still to be possible to argue about whether the cellulose chain molecules are all oriented in the same sense, or form two antiparallel systems D W Jones and his colleagues (British Rayon Research Association) are non-committal about it in their discussion of cellulose I, but favour alternation in cellulose II Prof R D Preston (Leeds) suggests that in cellulose I alternation is unlikely, basing his argument on the idea that growth is by end-synthesis His conclusion was, however, criticized in discussion, and also seems impossible to reconcile with the almost universal acceptance of alternation in cellulose II, although whether this is necessary or merely a convenient dogma is not at all clear It does seem reasonable to expect that, if chain polarity is of any significance at all, the same type of arrangement will be present in both modifications

Another controversial feature is the type of hydrogen bonding, about which there are two schools of thought respectively accepting or denying the presence of diagonal hydrogen bonds (specifically perpendicular to the [101] normals in the Meyer and Misch cell) The orthodox, among them the British Rayon Research Association team, agree with Meyer and Misch at least on this one point, that the hydrogen bonds are parallel to the *a*-axis of the unit cell. Both schools have recently adduced infra-red absorption results in favour of their arguments, creating further confusion for the non-specialist

Agreement does seem to be reached on one point, that there is more than one cellulose I structure, the eucellulose (Preston) or type *A* cellulose (Marrinan and Mann) of *Valonia* must, one supposes, be cellulose I proper, ramie, the typical type *B* cellulose, is classed with most of the other plant fibres as yielding on hydrolysis, besides glucose, other sugars which are to be regarded as contaminants

Some fibrillar aspects of the fine structure of cellulose also received attention Preston believes that the microfibrils retain their identity when surrounded by incrustants in the cell wall, and that their surface structure is in some way responsible for the electron diffraction patterns which he and his colleagues have obtained from metal–cellulose complexes

The application of X-ray analysis to the problem of the structure of silk fibroin is nearly as old as its application to cellulose, and we have been accustomed for a long time to distinguish between the structures of the two principal silks of commerce, domestic and tussah It is now clear that these are but two of a family of at least six fibroins produced by various members of the orders Lepidoptera and Araneae, the silks produced by some fifty species were examined by J O Warwicker (Shirley Institute, Manchester) to establish this A disturbing observation is that there appears to be no strict correlation between the crystallographic type of the fibroin and the biological classification of the producing species Structurally, the fibroins differ in the separation of the hydrogen-bonded pleated sheets of polypeptide chains, this distance may be as small as 9 3 A (*Bombyx mori*) or as large as 15 7 A (*Nephila senegalensis*) In fibroins with the larger inter-sheet separations amino-acid residues with long side-chains must occur in the crystalline regions In view of the importance of this idea, which has always been virtually rejected before in theories of fibroin structure, further details of the relevant chemistry would be welcomed

The cross-β configuration, so extensively studied in the keratin–myelin–elastin–fibroin group of fibrous proteins, has always been something of a puzzle because of the difficulty of obtaining a good X-ray diffraction diagram That a solution of the problem should now be given in terms of a structure closely allied to a fibroin rather than to keratin is one of those oddities which sometimes arise in fibre structure research K D Parker and K M Rudall (Leeds) have found, in fact, a cross-β fibroin in the egg-stalks of the lacewing fly, it gives a remarkably good X-ray diffraction pattern the interpretation of which leaves no doubt that the fibroin chain-molecules are arranged in long folds transverse to the fibre-axis From this folded configuration the chains can be brought into the parallel-β state by stretching the material to about six times its initial length This change is regarded as a true intramolecular transformation like the α–β transformation in keratin, but differs from the latter in that so far no success has followed attempts to reverse the change

Heavy-metal staining techniques are of great importance in electron microscopy, and are now being successfully employed in studies of the microfibrillar texture of keratin fibres Work is going on in various centres to correlate such electron microscope observations with the older X-ray results that mercury, for example, can modify the intensities of the equatorial 'reflexions' at approximately 80 A, 45 A and 27 A in keratin H J Woods (Leeds) reported that staining with mercuric acetate also affects the wide-angle diffraction pattern, when corrections are made for increased absorption due to the metal In an attempt to account for the small-angle 'reflexions' in terms of a model of uniform microfibrils it is found that conventional Fourier transform methods for obtaining the radial distribution of interfibrillar vectors are inapplicable, and the direct method of calculating the intensity from an assumed radial distribution often results in a negative intensity In the discussion it was suggested that there might be a failure of the conventional theory for systems so nearly close-packed as those considered, but it now seems more likely that the difficulty is due to the fact that for such systems the radial distribution must be so nearly determined by geometry that the use of an arbitrary distribution may well be physically unsound J Sikorski emphasized that the electron microscope results so far tell us only about the details in para-cortical cells, the size and packing of the microfibrils in the ortho-cortex may well be different H J WOODS

THE SMITHSONIAN INSTITUTION

REPORT FOR 1957–58

THE report of the Smithsonian Institution for the year ended June 30, 1958*, covers the 112th year of the Institution and includes the report of the Secretary and the financial report of the Executive Committee of the Board of Regents, together with reports of branches of the Institution and on the library and publications The Institution has now nearly 51 million catalogued objects in its collections, and visitors to all its branches totalled more than 10 36 million Field work during the year included the excavation of the Welcome Mound along the Ohio River in West Virginia, continued field investigations of the bird-life of the Isthmus of Panama, and the mammal survey of Panama, a long-range programme designed to solve the stratigraphic sequence in the Glass Mountains, and extensive palæontological work in Oklahoma, Texas, New Mexico and Colorado

Systematic researches by the staff of the Bureau of American Ethnology included Eskimo and arctic studies, field-work in South Carolina, among the New York Seneca and in Florida, and excavations at Russell Cave, Alabama The director of the Bureau continued also as director of the River Basin Surveys, which continued its programme for salvage archæology in areas to be flooded or otherwise destroyed by the construction of large dams By June 30, 1958, 254 surveys and excavations had been made in twenty-nine States and 4,889 archæological sites located, of which 997 had been recommended for excavation or limited testing; by the end of the year, 388 sites in fifty-two reservoir basins in nineteen States had been partly or extensively dug

The Smithsonian Astrophysical Observatory continued to work along the four principal lines of solar astrophysics, meteors, the satellite tracking programme and studies of the upper atmosphere, in which methods based on celestial mechanics were developed for inferring the density of the upper atmosphere from the motions of artificial Earth satellites, and a theoretical study of the nature and thickness of the lunar dust layer was completed Its Division of Radiation and Organisms continued studies on photomechanisms in plants, with special emphasis on growth responses controlled by low levels of red and blue radiant energy Studies of the interaction of gibberellin, kinetin and cobalt with the photo-process indicate that there is no direct interaction between red irradiance and the added substances, although all these materials modify the final growth response Studies were continued on the effects of radiant energy on the biosynthesis of protochlorophyll in leaves of higher plants grown in the dark, and in a study of biochemical changes involved in the development and maturation of the chloroplast of higher plants, some progress was made in isolating intact proplastids from leaves grown in the dark

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* Smithsonian Institution Report of the Secretary and Financial Report of the Executive Committee of the Board of Regents for the year ended June 30, 1958 Pp x+232+14 plates (Washington, D C Government Printing Office, 1958)

Good progress is reported in locating a site for a new building for the National Air Museum, to which 193 specimens in 52 accessions were added during the year The National Zoological Park, to which 1,411 animals were added during the year, now totals 2,316 individual specimens, and visitors exceeded 4 million, while those to the Canal Zone Biological Area totalled 570, of whom forty-three were scientists, students or observers using the station for scientific work, particularly in wild-life observation, plant and insect studies and photography The International Exchange Service handled 1,094,798 packages, including 63 full and 43 partial sets of United States official publications in exchange for official publications sent by foreign Governments for deposit in the Library of Congress The Library received 53,274 publications during the year, and arranged 128 new exchanges Its holding at the end of the year totalled 974,893, including 586,722 in the Smithsonian Deposit at the Library of Congress The report includes a list of the 81 new Smithsonian publications issued during the year

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EFFECT OF NITROUS ACID ON TOBACCO MOSAIC VIRUS: MUTATION OR SELECTION?

By F C BAWDEN, F R S

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GIERER and Mundry[1,2] claim that treating preparations of tobacco mosaic virus or of its nucleic acid with nitrous acid *in vitro* causes mutations Indeed, they state that their "experiments show that replacement of one single NH_2-group by one OH-group *in vitro* can change the genetic character of the whole TMV-RNA molecule"[2] The genetical implications of this statement are so great that, before accepting it, there is more than usual need to ensure that their experiments could have no other interpretation What their results show is that, when tobacco mosaic virus is treated with nitrous acid, its infectivity, as measured by the numbers of local lesions formed in one tobacco variety, Xanthi, decreases, while the number of necrotic lesions produced in another variety, Java, increases Xanthi forms necrotic local lesions with all the usual strains of tobacco mosaic virus, whereas Java forms them with only some and not with the type strain

These results are readily reproducible Table 1 shows two experiments with the Rothamsted type culture of tobacco mosaic virus , in one, inoculations were made to Xanthi and Java and in the other to *Nicotiana glutinosa* L , which like Xanthi gives necrotic local lesions with the type strain, and to Judy's Pride, a variety of White Burley, which, like Java, does not The starting preparation, like those used by Gierer and Mundry, produced a few necrotic lesions on Java and Judy's Pride There is nothing unusual in this, for all bulk preparations of tobacco mosaic virus contain a mixture of strains However, this being so, it is obviously necessary to consider whether the change in behaviour of the preparations towards the different plants during inactivation by nitrous acid could simply reflect some form of selection from a mixed population of strains Gierer and Mundry state that this possibility is excluded because the total number of lesions produced on Java increases and not simply the ratio of lesions on Java to those on Xanthi They therefore conclude that the number of particles able to cause necrotic lesions on Java must have been increased by exposure to nitrite But must it ? Their conclusion rests on the assumption that strains do not interact and that one will always produce its characteristic effects regardless of how much of other strains is present

Table 1 NUMBERS OF NECROTIC LESIONS PRODUCED BY DIFFERENT *Nicotiana* SPECIES AND VARIETIES WHEN INOCULATED WITH TOBACCO MOSAIC VIRUS TREATED FOR VARIOUS TIMES WITH NITROUS ACID

Time (hr)	Numbers of necrotic lesions per leaf			
	Exp 1		Exp 2	
	Xanthi	Java	*N glutinosa*	Judy's Pride
0 0	300	0 5	350	2
0 5	250	9	300	12
1	122	24	210	20
2	98	26	130	28
4	33	12	60	33
20	6	0 5	10	15

Tobacco mosaic virus at 4 mgm /ml was incubated with 1 *M* sodium nitrite and 0 25 *M* acetic acid at *p*H 4 1 for the times stated, when samples were diluted 1/10 in *p*H 7 phosphate buffer and used as inocula Xanthi and *N glutinosa* give necrotic local lesions with the type strain of tobacco mosaic virus, Java and Judy's Pride do not

Table 2 NUMBERS OF NECROTIC LESIONS PRODUCED BY DIFFERENT *Nicotiana* VARIETIES AND SPECIES WHEN INOCULATED WITH MIXTURES OF TOMATO AUCUBA AND TOBACCO MOSAIC VIRUSES

Inoculum	Numbers of necrotic lesions per leaf			
	Exp 1		Exp 2	
	Xanthi	Java	*N glutinosa*	Judy's Pride
Aucuba alone	95	240	66	75
Aucuba in TMV 20 mgm /l	130	180	128	60
Aucuba in TMV 200 mgm /l	380	24	350	14
Aucuba in TMV 2 gm /l	500	2	400	4
TMV 2 gm /l alone	500	3	450	2

The tomato aucuba mosaic virus was used at 10 mgm /l With the high concentrations of tobacco mosaic virus (TMV) the lesions on Xanthi and *N glutinosa* were too many to count accurately

There is much evidence at variance with this assumption For example, it has long been known that infection of a plant with one strain of tobacco mosaic virus prevents other strains from producing their characteristic effects[3] and that adding type tobacco mosaic virus to inocula of strains that produce necrotic lesions in Judy's Pride tobacco decreases the number of lesions they produce[4] One such strain is tomato aucuba mosaic virus, and Table 2 shows how mixing this with various amounts of tobacco mosaic virus can affect the number of necrotic lesions formed on Java and Judy's Pride Decreasing the amount of tobacco mosaic virus reproduces the phenomenon, which in treatments with nitrite Gierer and Mundry say can only be attributed to mutations, of decreasing the numbers of lesions produced on Xanthi and *N. glutinosa* while the numbers on Java and Judy's Pride increase. Numbers of necrotic lesions, however, do not tell the whole story, for mixing aucuba mosaic virus with tobacco mosaic virus alters the type of lesion produced, especially on Java. Aucuba mosaic virus alone produces distinctive, reddish-brown circles that may reach a diameter of 0.5 cm. None of the lesions recorded in Table 2 as formed by inocula containing the larger amounts of tobacco mosaic virus was of this type, but all were white spots and flecks of various sizes. With smaller amounts of tobacco mosaic virus, the lesions were more variable; some were all white, but others had small reddish-brown centres, and some approximated to true aucuba type. More of the last type occurred as the concentration of tobacco mosaic virus decreased.

Similarly, when mixtures containing 4 mgm./ml. tobacco mosaic viruses and 20 mgm./l. aucuba mosaic virus were diluted 1/10 in *p*H 7 phosphate buffer and inoculated to Java, only white lesions were formed, whereas a range of types was produced after incubation with nitrite. The first brown lesions to appear were small, but as the treatment continued they became more typical of the aucuba type. It is highly unlikely that adding aucuba mosaic virus to the starting preparation directed any mutations caused by nitrite towards characters peculiar to aucuba mosaic virus, and a more reasonable interpretation is that the residual aucuba mosaic virus became increasingly able to make itself evident as the concentration of infective tobacco mosaic virus decreased. This interpretation does not demand that aucuba mosaic virus should be more resistant than tobacco mosaic virus to inactivation by nitrite, for the ability of the latter to obscure the presence of aucuba mosaic virus is not determined only by the proportions of the two. Concentrated tobacco mosaic virus will obscure proportionally more than will dilute virus; for example, whereas 2 gm./l. will obscure 20 mgm./l. aucuba mosaic virus, 0.2 gm./l. will not necessarily mask 2 mgm./l.

The fact that the obscuring ability of tobacco mosaic virus increases with increasing concentration may simply reflect one aspect of the well-known interference phenomenon, that infection by one strain makes cells resist infection by others. The more concentrated the tobacco mosaic virus, the more epidermal cells it will infect at inoculation and the fewer there will be for aucuba mosaic virus to multiply in unhindered. Indeed, the range of local-lesion types in Java produced by mixtures of the two may mean only that, in different parts of the leaf, different proportions of cells contain one or other of the two strains. However, it is equally possible that there are other interactions between the strains as they multiply, leading, perhaps, to genetic recombinations or phenotypic mixing. This could be decided only by isolating the viruses present in different lesions and testing their behaviour when transmitted to a range of plants. Whatever may be the mechanisms of the interaction between strains, there is no doubt that strains able and unable to cause necrotic lesions in Java tobacco do interact and that this interaction affects both the quantity and quality of lesions produced. The experiment recorded in Table 2 shows fewer local lesions on Java when aucuba mosaic virus was mixed with tobacco mosaic virus than when inoculated alone; but the mixtures sometimes produced more lesions, though no lesion was then of the aucuba type and all were white spots, rings or flecks. Obviously the interactions are complex, but the fact that they occur makes the counts of necrotic lesions produced by mixtures of strains valueless for indicating the numbers of particles present that are intrinsically able to cause necrosis in Java. There seems no reason to look further for an explanation of the action of nitrite in increasing the numbers of lesions produced by tobacco mosaic virus in Java than that, as the concentration of particles unable to cause necrosis decreases, so they interact less with those able to cause necrotic lesions.

The phenomena that suggest mutation come from interactions between infective particles; but there is also an interaction between virus inactivated by nitrite and active virus. Inactivation by nitrite is an effect on the nucleic acid, and inactivated virus particles still retain their physical and serological properties, as do those inactivated by ultra-violet radiation. Like virus inactivated by ultra-violet radiation[5], and like the protein produced when virus particles are disrupted by alkali[6], nitrite-inactivated virus inhibits infection by active particles, and the presence of 0.4 mgm./ml. of such inactivated virus will halve the number of lesions produced by tobacco mosaic or aucuba mosaic virus at 10 mgm./l. This inhibition could affect measurements of inactivation rates, for as the amount of inactivated virus increases so it will increasingly inhibit infections by the residual infective virus, the amount of which will thereby be increasingly under-estimated and preparations will cease to infect while they still contain potentially infective particles. The virus protein is likely to be responsible for the inhibition, so tests with nucleic acid preparations are probably free from this complication; it was with these that Mundry and Gierer[2] found that inactivation follows first-order kinetics. Their conclusion that changes in single NH_2-groups cause mutations derives from the observation that the numbers of necrotic lesions produced on Java at first increase linearly with time; but this need mean little more than that the dominating strain in their starting preparation inactivated according to first-order kinetics. That their starting preparation did contain strains already able to cause necrosis in Java is clear, and that these were interacting with other strains is strongly suggested by the fact that, when diluted 1/10, the number of necrotic lesions on Xanthi fell to one-fifth whereas the number on Java was only halved.

The isolations Mundry and Gierer[2] made from single local lesions in Xanthi also show their starting preparation was mixed. Most of the isolates made from 60 lesions produced by nucleic acid after 90-min. exposure to nitrous acid differed from type tobacco mosaic virus, whereas only 1 out of 65 isolates made from the starting preparation was obviously different. This fact they advance as further evidence that nitrite caused mutations; but as the treated preparation had lost more than 99 per cent of the initial infectivity, 99 times as many lesions should have been sampled from the untreated as from the treated preparation to make a proper comparison. Had 6,000 lesions been sampled, there is every reason to think that more than 100 isolates differing from tobacco mosaic virus would have been found, for the fact that one was identified for certain from 65 lesions suggests that at least 2 per cent of the particles in the starting material differed from type tobacco mosaic virus.

I have made no tests to see whether different strains differ in the rate at which they are inactivated by nitrite; but it is to be expected that they will, for strains have been found to differ in their susceptibility to inactivation by most other treatments. The obvious place to look for resistant strains is among those that survive at the tail end of an inactivating treatment, and all that is needed to explain the preponderance of variants after exposure to nitrite is to postulate that strains differ in their rate of inactivation. That the isolates when propagated continued to show their characteristic differences from type tobacco mosaic virus is interesting, but has no relevance to the problem of how they came to be genetically different from the type virus. Mutations no doubt reflect chemical changes in the nucleic acid, and there is no *a priori* reason why changes produced *in vitro* should not affect the genetic behaviour of viruses, but to attribute mutations to such changes requires more than demonstrating that the end-products of an inactivating treatment differ in behaviour from the bulk of the starting material; it requires demonstrating that chemical changes produced *in vitro* are perpetuated in the progeny of the particles.

I am indebted to Dr. A. Gierer for providing me with seeds of the tobacco varieties Xanthi and Java.

[1] Gierer, A., and Mundry, K.-W., *Nature*, **182**, 1457 (1958).
[2] Mundry, K.-W., and Gierer, A., *Z. Vererbungslehre*, **89**, 614 (1958).
[3] Thung, T. H., Z. Ned.-Indisch Natuurwetensch. Congr. Bandoeng, Java, 450 (1931).
[4] Sadasivan, T. S., *Ann. App. Biol.*, **27**, 359 (1940).
[5] Bawden, F. C., and Kleczkowski, A., *J. Gen. Microbiol.*, **8**, 145 (1953).
[6] Bawden, F. C., and Pirie, N. W., *J. Gen. Microbiol.*, **17**, 80 (1957).

CHARACTERS ASSOCIATED WITH PARASITISM IN GRAM-POSITIVE BACTERIA

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THE concept of parasitism in bacteria has been overshadowed by the more immediate problems of pathogenesis, so that, in standard bacteriological literature, the words parasite and pathogen are treated as if they were synonymous, and harmless parasites are inaccurately designated commensals. Parasitism, properly so called, is common among bacteria, especially of the Gram-positive group, and it is the purpose of this article to indicate certain interesting conclusions that are derived from a consideration of the characters associated with its occurrence.

Many members of the Gram-positive group are not, in fact, Gram-positive in their staining reactions, but nevertheless bear so close a resemblance to the other members of the group in every other respect that they must be considered to have lost this characteristic secondarily. In very many instances, these are parasitic representatives of mainly free-living families. An obvious example is *Neisseria*, a genus consisting of obligate parasites, many of which have lost all trace of Gram-positivity, while retaining characters of morphology, metabolism, antibiotic sensitivity, etc., that indicate a relationship with the Coccaceae. (Their description as obligate parasites refers to their normal mode of life, and does not exclude the possibility of growth in artificial culture.)

A second important character associated with parasitism is anaerobiosis. So far as I am aware, all truly Gram-negative bacteria are aerobic; the so-called Gram-negative anaerobes, such as *Veillonella*, *Fusobacterium* or *Bacteroides*, have obvious affiliations with Gram-positive families, and these also are obligate parasites. This combination of characters is well known in the facultatively parasitic clostridia, many of which are very weakly Gram-positive, whereas the aerobic, sporing bacilli, few of which are parasitic, are strongly Gram-positive. Anaerobiosis without loss of Gram-positivity is found in the parasitic *Actinomyces*. The streptococci would serve as examples, in view of their lack of catalase, but most species are aerobic by virtue of their insensitivity to hydrogen peroxide.

The third character associated with parasitism in Gram-positive bacteria, as indeed in animals and higher plants also, is loss of structural complexity; although the bacteria are exceptional in that they commonly undergo a reduction in the organs of distribution.

Thus, in respect of these various characters, there is quite often found to exist a series of forms connecting a Gram-positive, aerobic saprophyte of complex morphology, with a Gram-negative, anaerobic parasite of simple morphology.

(*A*) The free-living sarcinae are large and strongly Gram-positive; they are aerobic, and include representatives which, by virtue of their possession of flagella and spores, attest a recent common origin with the sporing bacilli. The facultatively parasitic micrococci and staphylococci are Gram-positive and aerobic, but smaller and devoid of flagella and spores. The parasitic *Neisseria* are aerobic, but Gram-variable or negative; and the *Veillonella*, in addition to these characters, are anaerobic and very small indeed.

(*B*) The free-living streptomyces are large and strongly Gram-positive; they are aerobic and they branch and sporulate very freely. The large oral leptotrichia are aerobic and Gram-positive; they branch freely and form very occasional chains of spores[1]. The classical type of *Leptotrichia buccalis* is microaerophilic and Gram-variable; it branches rather rarely and does not appear to form spores[1]. Fusobacteria resemble *L. buccalis* very closely in general morphology, but are very small, Gram-negative, anaerobic and do not branch. All the last three are obligate parasites, but they are progressively more difficult to cultivate, in the order given. The origin of the anaerobic, Gram-negative *Bacteroides*, which bears some resemblance to the fusobacteria, is probably similar.

(*C*) The true *Actinomyces* (a genus of oral parasites typified by *A. bovis*) resemble *Micromonospora* in their main morphological features, but are anaerobic or microaerophilic and structurally degenerate[2].

If the conclusions arising from these observations are valid, it would appear that the great majority of parasitic bacteria of the Gram-positive group are descended from more complex, free-living ancestors This is, of course, a biological commonplace, but systematic bacteriology has not yet fully recovered from the effects of placing a very undue emphasis upon the taxonomic characters of those common pathogens, usually members of parasitic genera, with which the majority of bacteriologists are, or previously were, most closely acquainted, without taking into consideration the possibility of such tendencies as have just been described

The suggestion that structurally complex Actinomycetes are ancestral to simpler forms, and even to cocci, is not new[4] , but former hypotheses of this type have tended to suggest the sort of relationship that exists between the mycelial and oidial fungi, rather than a progressive degeneration of structure, associated with anaerobiosis or loss of Gram-positivity, and sometimes with both

It is not, however, easy to understand how these bacteria are able to dispense with the production of catalase and of the nucleic acids of the Gram-complex[3], which appear to be essential, or very advantageous, to their free-living counterparts In the case of the bowel-dwelling forms, it is possible that their environment protects them against free oxygen , but whereas neither *Clostridium*, *Bacteroides*, '*Lactobacillus bifidus*' nor *Streptococcus faecalis* produces catalase, the truly Gram-negative intestinal bacteria do so in every case Nor is the alternative explanation, that the anaerobes of the mouth, for example, live in such close association with large numbers of other bacteria as to profit from their catalase production or oxygen utilization, any more satisfactory, since the oral flora consists very largely of anaerobes or non-catalase-producing aerobes, such as streptococci and lactobacilli The animal tissues themselves are the only probable source of the enzyme

The significance of the loss of the Gram-complex in so many parasites is almost beyond speculation, but it is at least possible that it indicates the availability, in an elaborate form, of nutrients, with the synthesis of which from simpler materials these nucleic acids are concerned, under less-favourable conditions

[1] Baird-Parker, A C , and Davis, G H G , *J Gen Microbiol* , **19** 446 (1958)

[2] Bisset, K A , *J Gen Microbiol* , **17**, 562 (1957)

[3] Henry, H , and Stacey, M , *Nature*, **151**, 671 (1943)

[4] Viscentini, F , "Bacteria of the Sputa and Cryptogenic Flora of the Mouth" (Bailliere, Tindall and Cox, London, 1897)

DEVELOPMENT OF *TRYPANOSOMA VIVAX* TO THE INFECTIVE STAGE IN TSETSE FLY TISSUE CULTURE

By Dr WILLIAM TRAGER
Rockefeller Institute, New York 21

EARLY in the work on trypanosome diseases of man and animals in Africa, it was found[1] that cultures of trypanosomes could be obtained quite readily in blood agar media inoculated with infected blood and incubated at temperatures of 25–30° C But at the same time came the disturbing finding that such cultures lost their infectivity as soon as they began to grow[1,2] What was happening soon became clear in the cultures there developed only the so-called midgut forms of the trypanosomes, the same forms which develop in the midgut of an infected tsetse fly and which Bruce[3] had shown to be non-infective to the mammalian host In a suitable tsetse fly, however, the trypanosomes migrate to the salivary glands and proboscis, where they become transformed into infective forms[4] Recently, Weinman[5] reported in a preliminary way that he had produced infection in mice with two cultures of *Trypanosoma rhodesiense* maintained in a medium with trehalose (concentration not stated) With this exception, infective forms of the African trypanosomes have not previously been obtained in culture It seemed possible that these metacyclic forms might develop *in vitro* in the presence of surviving or growing tsetse fly tissue

The gonads of female lepidopterous larvæ are the only insect tissue that has up to now given outgrowths of cells at all comparable to those obtained with vertebrate tissues[6–8] Although mosquito tissues survived *in vitro* sufficiently well to support the growth of western equine encephalitis virus[9], they did not produce cellular outgrowths, nor have such outgrowths been obtained with tissue from other dipterous insects The cultivation of tsetse fly tissue was therefore a problem of considerable intrinsic interest, quite apart from its bearing on the developmental cycle of trypanosomes It is the purpose of the present brief report, however, to relate only the main results of the experiments dealing with the production of infective trypanosomes *in vitro* The complete details of these experiments, together with full information on the tsetse fly tissue cultures, will be reported elsewhere

Tissues of the fly *Glossina palpalis* were obtained from pupæ or young adults free from extraneous bacteria Pupæ of known age (sent to me from the Kaduna Laboratory of the West African Institute for Trypanosomiasis Research through the kindness of Mr W MacDonald) were sterilized externally in White's solution (mercuric chloride, 0 25 gm , sodium chloride, 6 5 gm , hydrochloric acid, 1 25 ml , ethanol, 250 ml ; distilled water, 750 ml), rinsed in sterile water and dried on sterile filter paper in a Petri dish Such pupæ, if kept for the required time in sterile vials with sand, produced bacteria-free adults The pupæ or adults were dissected aseptically in a drop of culture medium Fragments of tissues were explanted either in hanging drops or in a thin layer of fluid (0 3 ml) on the bottom of a Porter flask closed with a silicone rubber stopper

The culture medium (Table 1) supported initial outgrowths from, and differentiation of, several kinds of tsetse fly tissue In one type of outgrowth, mitotic division of the cells was seen To obtain cultures of trypanosomes, however, tissues were used which lived *in vitro* but showed limited or no outgrowth These tissues were the alimentary tract and salivary glands of a late pupa or a newly emerged fly To a

Table 1 PREPARATION OF THE CULTURE MEDIUM

*Solution A**	mgm /100 ml
NaCl	90
KCl	300
$NaH_2PO_4\ H_2O$	110
$MgSO_4\ 7H_2O$	370
$CaCl_2$	80
Glucose	150
Trehalose	50
1-Malic acid	50
α-Ketoglutaric acid	25
Succinic acid	5
Lactalbumin hydrolysate	1,000
Yeast extract ('Difco')	200

* Based in part on work of Wyatt (ref 7) and Grace (ref 8)

Ingredients were dissolved in water redistilled in a 'Pyrex' glass still *p*H was adjusted to 6 8 with 1 0 *N* NaOH The solution sterilized through a 'Selas' 03 porcelain filter

Solution B†	mgm /10 ml
Reduced glutathione	200
Ascorbic acid	2

† Sterilized through ultrafine glass filter

Final mixture Mix 8 ml of solution *A*, 2 ml sheep serum, 0 5 ml solution *B*

In 1 ml of the above mixture in a centrifuge tube, crush gently two sterilized 12-day-old pupæ of *G palpalis* Centrifuge 15 min at 2,000 r p m The supernatant with the re-suspended fatty layer at the surface constitutes the culture medium

hanging-drop culture was added a minute drop of blood or trypanosome concentrate from an infected animal Continuous culture was achieved of all three species of trypanosomes tried *Trypanosoma brucei*, *T congolense* and *T vivax*

The most interesting results were obtained with *T vivax*, a species never before cultured and which, in the tsetse fly, omits the midgut phase and develops directly to the infective forms in the proboscis A first attempt at cultivation of this species in fly tissue culture, using washed trypanosomes from a heavily infected sheep, gave a negative result In the second attempt, the only sheep showing trypanosomes on that day was one, infected by fly-bite nine months previously, which had survived the acute infection and now occasionally showed small numbers of organisms in the peripheral blood A concentrate from this blood, in which only one trypanosome could be seen per low-power field, was inoculated to fly tissue cultures prepared two days previously Two days later it was noticed that the temperature of the incubator (set for 28° C) had gone up to 30° C At this time large syncytial multiplying forms of trypanosomes were seen in the tissue cultures From these a strain was established and maintained in tissue culture for three months It was discontinued only because the work was brought to a close Soon after its establishment the strain was successfully transferred to blood agar slants and is still being maintained in this way Later experiments then showed that *T vivax* could be started in culture only by following the conditions which had occurred quite fortuitously the first time, that is, using blood from the sheep with a long-standing chronic infection, inoculating the concentrate of trypanosomes to tissue cultures two days old, and—very important—incubating these at 30–32° C, not at 27–29° C Once started, the cultures can be kept equally well at either the lower or the higher temperature, but they have mostly been kept at the higher temperature

Four strains of *T vivax* in tissue culture have been begun, three from the original sheep and a fourth from a new infection in a sheep inoculated with blood from the original sheep The first two culture strains have been studied in some detail There were present in the cultures numerous forms morphologically indistinguishable from the classical infective forms of *T vivax* as seen in the proboscis of the tsetse But five sheep inoculated repeatedly with such material and followed for more than a month failed to show trypanosomes in the blood Two of the sheep did have a fever, one on the eighth and the other on the ninth day after intravenous inoculation of culture material, but no trypanosomes could be found

It was then decided to test the ability of the trypanosomes in fly tissue cultures to survive at body temperature, which is lethal to the usual culture of trypanosomes on blood media A three-day-old hanging-drop subculture of strain 2 of *T vivax*, in culture for six weeks, was placed in a jar immersed in a water-bath at 38° C On the following day the culture presented a mass of very active trypanosomes The material was inoculated intravenously into a sheep Exactly one week later, scanty trypanosomes were present in the blood of this sheep They were readily identified as *T vivax* The sheep was positive again on the following day, with about three trypanosomes per field This sheep first showed fever (105° F) on the ninth day, the only day of fever it has had At this time no trypanosomes could be found, and it has since remained negative except for the thirteenth day (1 trypanosome in 150 fields) and the eighteenth day (1 trypanosome in 40 fields) Thus, transmission from culture was accomplished

Attempts at repetition of this success were immediately instituted An interesting finding was that whereas some tissue cultures of *T vivax* showed mostly dead or sluggish organisms after exposure to 38° C, others were very active, like the culture which produced infection A clean sheep raised at the laboratory was inoculated with a culture of *T vivax* which had numerous active trypanosomes after the one day at 38° C This sheep showed a positive blood film and had a fever on the seventh day after inoculation

These two successful transmissions from culture make it certain that a reproducible method is now to hand for obtaining infective *T vivax in vitro* This makes possible a detailed study of the factors responsible for the acquisition of the infective state by trypanosomes, a matter of significance far beyond its immediate application in the field of trypanosomiasis The relatively light infections which seem to have followed the inoculation of cultured *T vivax* suggest the possibility of the development of a practical method for immunization against the parasite, using attenuated but infective cultures This possibility requires and deserves much further investigation

The work summarized in the foregoing report was done while I was a visiting investigator at the West African Institute for Trypanosomiasis Research, and I thank Dr T A M Nash, director of the Institute, and Dr R S Desowitz, in charge of protozoology there, for their kind invitation to work in their laboratories and for the facilities extended to me by them and their staff Travel to Africa was made possible by a grant from the Rockefeller Foundation

[1] Thomson, J G, and Sinton, J A, *Ann Trop Med Parasitol*, **6**, 331 (1912)
[2] Tobie, E, *J Parasitol*, **44**, 241 (1958)
[3] Bruce, D, Hamerton, A E Bateman, H R, and Mackie, F P, *Proc Roy Soc*, B, **83**, 513 (1911)
[4] Kleine, F K, *Deut Med Wchnschr*, **35**, 1257 (1909)
[5] Weinman, D, *Trans Roy Soc Trop Med Hyg*, **51**, 560 (1957)
[6] Trager, W, *J Exp Med*, **61**, 501 (1935)
[7] Wyatt, S S, *J Gen Physiol*, **39**, 841 (1956)
[8] Grace, T, *J Gen Physiol*, **41**, 1027 (1958)
[9] Trager, W, *Amer J Trop Med*, **18**, 387 (1938)

LETTERS TO THE EDITORS

GEOPHYSICS

Disturbance in the Ionospheric *F*-Region following the Johnston Island Nuclear Explosion

According to the newspaper reports, American scientists exploded hydrogen bombs near Johnston Island on August 1 and 12, 1958, at heights of 160 km and 100 km The Apia magnetic records (Lawrie, J A, and Gerard, V B, private communication) give times as 10 50 and 10 30 G M T Some geophysical aspects of these explosions have been discussed by Cullington[1] and Kellog *et al* [2]

Here we will describe one of the effects on the ionospheric *F*-region We have 10-min recordings over the period of the first event and 2-min recordings over the period of the second event

Prior to both events, ionograms at Rarotonga showed the normal undisturbed night *F*-region On August 1, the ionograms 40 min after explosion (zero plus 40 min) showed a great increase in maximum electron density, and 10 min later this had exceeded the recording limit of the machine In the next 40 min the electron density decreased rapidly and at zero plus one hundred there was no trace of the normal *F*-region, but above it at a base height of 560 km was seen a layer the maximum electron density of which was roughly one quarter of the normal *F*-value The increase at the maximum phase was to at least seven times normal Another interesting characteristic was the gradual drop of fifty kilometres in height as the ionization decayed Fig 1 is a schematic diagram deduced from the ionograms

On August 12, the disturbance in the *F*-region took longer to reach Rarotonga and was much less severe A detailed true height analysis of these records confirmed the form deduced for the first event and ensured that no significant phases were missed We will discuss only the first event

In order to gain a better picture of the physical process we examined also the ionograms for Christchurch, 44° S, and Campbell Island, 53° S, and, through the courtesy of J A Lawrie and V B Gerard, the magnetic vectors which they had prepared for Honolulu, Palmyra Island, Fanning Island, Jarvis Island and Apia

A characteristic movement among the magnetic vectors was identified with the passage of the *F*-region disturbance The times of passage of the disturbance at the eight stations were then plotted against distance from the point of explosion (see Figure 2 *A*) The points lie well on the smooth curve except for Jarvis This Station is on the dip equator, and there is reason for supposing that the time of its vector is advanced by several minutes. The corresponding velocities are shown in Fig 2 *B*, values are only approximate because of limited data and time resolution

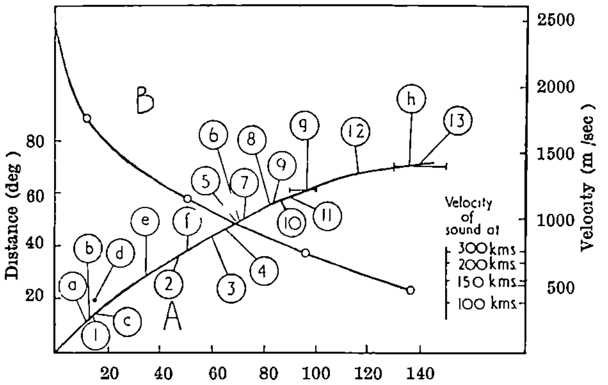

Fig 2 *A*, Curve of delay times versus distance in degrees *Observation sites* *a*, Palmyra Island, *b*, Honolulu, *c*, Fanning Island, *d*, Jarvis Island, *e*, Apia, *f*, Rarotonga, *g*, Christchurch, *h*, Campbell Island *Places where observations possible* 1, Maui, 2, Adak, 3, Guam, 4, San Francisco, 5, Kokubunji, 6, Akita, 7, Wakkanai, 8, Townsville, 9, Yamagawa, 10, Brisbane, 11, Okinawa, 12, Baguio, 13, Hobart *B*, Deduced velocity curve

The assumption made in drawing this smooth curve is that the velocity of propagation is independent of direction relative to the Earth's magnetic field Attempts were made to reconcile the time delays with a field-dependent velocity but no reasonable pattern emerged It seems, then, that the ionospheric disturbance is a by-product of a gaseous wave which is propagated at a velocity considerably above that of sound For convenience we will refer to it as a shock wave

It is not possible to account for the high value of electron density and its spatial distribution over Rarotonga merely by compression or even by the collection of all the electrons between Johnston Island and Rarotonga Restraint by the Earth's magnetic field of the motion of charged particles precludes electrons coming from the nuclear event itself Together with the complete disappearance of electrons after the disturbance, and the general appearance of the ionograms, these facts indicate electron production in the disturbance We postulate ionization by collision and subsequent removal by

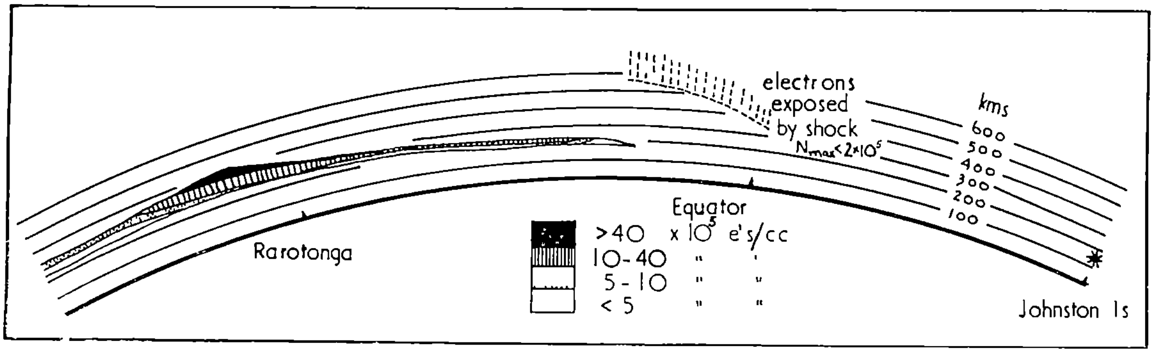

Fig 1 The spatial form of the ionospheric disturbance as deduced from the Rarotonga ionograms for the event of August 1

attachment or re-combination in a region of relatively high gas pressure

However, it does not seem possible that the main body of the gaseous shock wave travels in the region where the ionospheric disturbance is observed (200–550 km height), for the compression ratios of a shock wave of this velocity are insufficient to produce the observed ionization, and, moreover, there is not enough gas at this level to explain the extended front The apparent velocity at Campbell Island is below the velocity of sound at F-region height, while the characteristic form of the disturbance is maintained (increase in electron density with subsequent decrease in both density and height—no complete electron removal at this distance) Instead of a simple shock, we seem to have a supersonic surface wave of vertical extent much less than the wave-length, and the very high compression ratios producing the observed ionization are on its upper boundary We do not feel competent at present to discuss this wave further

As will be seen from Fig 2 *A*, many ionospheric stations are in regions where they may have recorded the characteristic movements associated with the wave Here is an ideal opportunity for international co-operation in an important study on atmospheric properties

This work will be reported more fully in the *N Z Journal of Geology and Geophysics*

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[1] Cullington, A L , *Nature*, **182**, 1365 (1958)

[2] Kellog, P J , Ney, E P , and Winckler, J R , *Nature*, **183**, 358 (1959)

Geomagnetic and Ionospheric Phenomena associated with Nuclear Explosions

NUCLEAR explosions at high altitudes were carried out at Johnston Island (geographically 16 7° N , 169 4° W , geomagnetically 14 3° N , 256 5° E) at 10 50 G M T on August 1 and at 10 30 G M T on August 12, 1958[1] Auroræ associated with these explosions were observed on both days at Honolulu[2] and Apia[3] Apia auroræ on August 1 have been discussed by Cullington[3], Fowler *et al*[4], Kellogg *et al*[5] and Elliot *et al*[6] In this communication geomagnetic and ionospheric effects associated with these events are described from the International Geophysical Year obtained at various stations in the Pacific area and the American continent

Immediately after the explosions, magnetograms showed sudden unusual variations at five stations in the central Pacific—Honolulu, Palmyra Island, Fanning Island, Jarvis Island and Apia The variation at Honolulu had the form of an intense bay disturbance The variation at the other four stations was somewhat like an unusually short-period magnetic storm (about 1 hr) with a sudden commencement Moreover, the sudden commencement at Apia showed an initial short reverse impulse (SSC^{*}) as reported by Cullington[3] These geomagnetic effects occurred similarly for both events, although the magnetic storm on August 12 was smaller than that on August 1, probably due to the lower explosion height

These associated geomagnetic storms indicated that counterclockwise circular electric currents were formed in the vicinity of Johnston Island immediately after the explosion, due to the dynamo effect caused by winds of charged particles which moved radially outward from the centre of the explosion In other words, if the wind velocity due to the explosion in the 80–100 km level became of the order of 100 m /s and the electrical conductivity increased by the order of 10 times due to high-energy particles and X-rays, the associated counterclockwise electric currents in the vicinity of Johnston Island would have been sufficient to give the observed magnetic variations even at places 1,300–2,200 km distant, such as Honolulu, Palmyra, Fanning and Jarvis Islands The geomagnetic effects observed at Apia could have resulted from these circular electric currents and an increase of the electrical conductivities in the 80–100 km level caused by β-decay electrons coming along magnetic lines of force from Johnston Island

The maximum geomagnetic change at Honolulu occurred around the time at which a shock wave from the explosion arrived at Maui, as mentioned below It is possible, therefore, that there was an additional effect increasing the intensity of the electric currents just at the moment when the shock wave hit This could have been caused by a dynamo effect resulting from the shock wave

At the Maui Ionospheric Station in the Hawaiian Islands a sudden increase of $f_{\min}$ (the minimum frequency of the observed radio echo) was observed at 10 50 22 ± 7 G M T on August 1 lasting several minutes, and again at 10 30 37 ± 7 G M T on August 12 for a few minutes These changes were similar to a solar flare effect However, since they occurred during local night, they must have resulted from the explosions Probably they were caused by ionization in the D-region by X-rays from the blasts

On August 1 a peculiar oblique echo began at Maui 13 min after the explosion and lasted until 11 12 G M T , when it was completely blanketed by increased ionization in the D-region This phenomenon may have been due to a shock wave caused by the explosion A no-echo phenomenon, called a 'blackout', began at 11 12 37 ± 7 G M T , about 22 min after the explosion, and continued until 13 20 G M T During this time a faint F-echo occasionally appeared After 13 20 G M T the $F2$-layer gradually appeared and recovered to normal

At Maui, between 10 56 G M T and 10 59 G M T on August 12, both the height and the critical frequency of the F-layer decreased abruptly At 11 03 G M T a stratification appeared in the F-layer and showed an unusual sequence of changes This sequence indicates that an irregular ionization in the F-layer, caused by a shock wave from the explosion, was propagated horizontally over Maui from the direction of Johnston Island The estimated speed of the shock wave is about 0 9 km /s for this event, and 1 3 km /s for the event on August 1 The wave motion created repeated irregular ionizations in the F-layer until a blanketing occurred A blackout occurred at 16 00 G M T , 5 hr 30 min after the explosion, and lasted 2 hr Even after that time there was severe absorption until 5 00 G M T on August 13 The behaviour of the ionospheric storm of August 12 was in general similar to the ionospheric storm of August 1 On August 12, however, the onset of the blackout was slower and the duration of the radio-wave absorption was much longer, in spite of a smaller geomagnetic effect The lower explosion height and the daytime onset of the blackout on August 12 may have been responsible for these differences

Rarotonga also showed explosion effects in the ionosphere for both events However, other ionospheric stations—Adak, San Francisco, Washington, White Sands, Huancayo, Godley Head and Okinawa —did not show any certain explosion effects Accordingly, it is concluded that direct-explosion effects on the ionosphere and the geomagnetic field occurred over an area in the central Pacific, roughly the region 170° E-150° W and 40° N-22° S Radio signals from Honolulu (10 and 15 Mc/s) and from San Francisco (13 75 Mc/s) received in Japan showed sudden drops[7] after both explosions These were due to radio absorption in that central Pacific region

From the present study of these geomagnetic and ionospheric effects, the explosion height is estimated as 70–80 km on August 1, and about 40 km on August 12, although the *New York Times* simply reported it as 100 miles on August 1 and lower than that on August 12

In addition, three other nuclear explosions that occurred in the south Atlantic on August 27, 30 and September 6, 1958, at about the 480-km level, were considered No remarkable geomagnetic and ionospheric effects directly associated with these blasts could be detected in the normal magnetograms or ionograms

Full details of this work will be published in the *Journal of Geophysical Research* I wish to express my thanks to Dr W O Roberts and Mr A H Shapley for their kind help, and to Mr D B Bucknam for his considerable assistance I am also grateful to the Boulder Laboratories of the National Bureau of Standards for an appointment as guest worker and for extending to me their facilities I wish to thank the International Geophysical Year Data Centers *A* for Geomagnetism and the Ionosphere for the use of data This study was supported by the National Academy of Sciences as part of the International Geophysical Year Programme with assistance from the Ford Foundation

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[1] *New York Times*, Aug 2 and 13 (1958), Mar 19, 20 and 26 (1959)

[2] Steiger, W R, and Krivoy, H L, *Hawaiian Acad Sci* (in the press)

[3] Cullington, A L, *Nature*, 182, 1365 (1958)

[4] Fowler, P H, and Waddington, C J, *Nature*, 182, 1728 (1958)

[5] Kellogg, P J, Ney, E P, and Winckler, J R, *Nature* 183, 358 (1959)

[6] Elliot, H, and Quenby, J J, *Nature*, 183, 810 (1959)

[7] Obayashi, T, Coroniti, S C, and Pierce, E T, *Nature*, 183, 1476 (1959)

Magnetic Effects Resulting from Two High-Altitude Nuclear Explosions

ON August 1 and 12, 1958 two nuclear devices were exploded in the upper atmosphere above Johnston Island in the North Pacific No exact information is available to us regarding the heights of the explosions, but it is believed that the first explosion was higher than the second Unusual magnetic effects, mentioned previously by Cullington[1], were recorded after both explosions on magnetographs at Honolulu, Palmyra Island, Fanning Island, Jarvis Island and Apia Fig 1 shows the location of these observatories

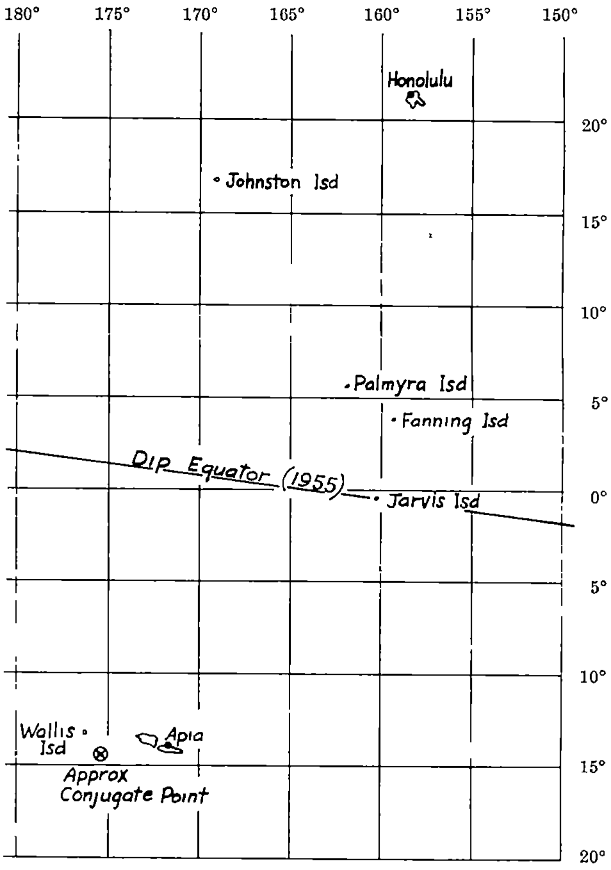

Fig 1 The region of the Pacific showing islands where unusual magnetic effects were recorded

Vector diagrams of the variations in a horizontal plane are shown in Fig 2*a* and *b* Fig 2*a* refers to the first explosion, and Fig 2*b* to the second The effects at Palmyra, Fanning and Jarvis are very similar, and only the Jarvis Island diagram is presented here Variations in a vertical plane are not illustrated, since the only important effect they reveal is a marked downwards movement in Z at Apia at about 10 55 G M T, following the second explosion

An examination of these diagrams has led us to classify the effects into four phases—initial, second, main and final, as labelled in Fig 2*a* and *b*

We suggest the following broad interpretations

Initial phase A hydromagnetic impulse affected by dispersion, corresponding to the Alfvén wave postulated by Kellog *et al* [2]

The front edge travels faster than 10^8 cm/sec and the time of the maximum corresponds to the speed of a transverse hydromagnetic wave of frequency 1 c/s travelling parallel to the magnetic field[3] Across the lines of force, the impulse travels at about the same speed, but suffers greater damping

Second phase Produced basically by the transport of individual β-particles[4], photoelectric and Compton electrons, and possibly ions along the line of force from above the point of the explosion to the conjugate point

As the shock wave and fireball move upwards, more and more individual charged particles can make their escape Radioactive decay of escaping high-energy neutrons probably broadens the region over which the transport occurs

As well as those magnetic fields due directly to the travelling particles, dynamo effects are caused by

(*Continued on page* 51)

BRITISH ASSOCIATION MEETING IN YORK

THE PROPER STUDY OF MANKIND IS MAN*

By SIR JAMES GRAY, C.B.E., F.R.S.
President of the British Association

I

IN the public mind, scientists are largely associated with the study of physical systems and practical problems; they are not directly concerned with moral principles nor are they responsible for the social repercussions of their discoveries. But it is impossible to be a scientist without being a human being and recognizing that social life depends as much on moral principles as on scientific knowledge. So far as science is mainly concerned with our material environment, it tends to isolate itself from the main factors which determine human behaviour. So far as the humanities are mainly concerned with Man's reactions to past environments, we cannot be quite sure how far their judgments are relevant to modern life. Such limitations will not be overcome by keeping our own particular type of knowledge in a water-tight compartment; the sciences and humanities should seek common ground. Hence the title of this address.

During the course of years, the need for a wider social outlook in science has been reflected by two important extensions in the range of the British Association's interests. It now includes the social as well as the natural and mechanical sciences, and it is more and more concerned with the dissemination of scientific knowledge to the whole community. But the wider the field and the larger the audience, the more difficult the task of presentation becomes. Scientists find it more and more difficult to keep abreast of all the main lines of development within their own subject, and almost impossible to know what is happening in other fields; we become more and more specialized and less and less able to see the wood for the trees. It might be said that one of the Association's most important functions is to bridge the gap between its different sections. In addressing the Association, its president has to decide whether he should speak as a specialist and make little or no attempt to relate his theme to wider issues, or whether to stray into unfamiliar fields, and run the risk of scientific, economic or political criticism[1]. Perhaps rashly, I have chosen to face these dangers, by trying to look at man from a biological point of view and to suggest how the picture might—here and there—merge into a wider background. But before doing so, I would like to touch on two quite general topics.

First, one of the most important social aspects of modern science is its repercussion on international relationships. Here there will always be potential danger and waste of human effort until individual nations can be persuaded to think in terms of the welfare of humanity as a whole. A scientific approach to such problems must be one of dispassionate analysis, but we shall not make much impression on public opinion so long as men's minds are biased by fear and suspicion; frightened or angry politicians, like frightened or angry animals, cannot be trusted to react wisely. There is not the slightest doubt, however, that the discoveries of physics *have* frightened mankind and that there are far too many intelligent people looking askance at science and wondering where it is leading them. In trying to link the sciences to the humanities our primary objective should be to depict man's position in the world of Nature as a source, not of fear or doubt, but of courage and inspiration. Our second main objective should be to demonstrate the place of science in a general philosophy of life. To be of real value, such a philosophy must rest on knowledge and experience which have already proved acceptable over a very wide range of local environments and national interests, and it must, at the same time, be closely concerned with problems of everyday life. In these respects science is unique. Except so far as they are subject to political restraint, scientists of all nations co-operate in solving Nature's jig-saw puzzles, and as Prof. A. V. Hill said at Belfast[2], "The fundamental principle of scientific work is the unbending integrity of thought, following the evidence of fact wherever it may lead within the limits of experimental error and honest mistake". This attitude of mind is not peculiar to scientists; it is common to all who have a respect for the truth. But in the fields of law, language, history, literature and, above all, politics, our general outlook and our individual range of knowledge depend to a very dangerous extent on local environment and national tradition. By freedom from such limitations science provides ground—perhaps the most solid ground—on which to base a wider range of co-operative effort. But the gap between a scientific and a humanitarian outlook cannot be bridged by the statistical laws of physics and chemistry; we are forced to apply the less precise, but not necessarily less important, principles to be derived from the world of living organisms. The challenge is, therefore, to the biological sciences, especially those which deal, at the borderline of sociology, with the behaviour of organisms and their relationship to their environment. Can they yield broad principles which are applicable to man, or must scientists be content to see the law of the jungle take its course except in so far as it can be restrained by humanitarian effort? The answers to such questions may well decide how far science can claim to be of direct cultural significance.

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* Presidential address delivered in York on September 2 and appearing in the September issue of *The Advancement of Science*.

II

Man's position in the world of Nature is brought most sharply into focus by the concept of natural evolution. Cosmic, biological and human evolution can be regarded as phases in a continuous natural process—and, from this point of view, astronomy, geology, biology, archæology and history form a continuous spectrum of knowledge. To pass from a primeval nebula to a modern man without any sudden break in continuity of thought gives a feeling of intellectual tidiness, but quite apart from this it helps us to visualize man against the background of his past and to regard him as Nature's supreme masterpiece. At the same time, he must not get *too* big for his biological boots or tend to exaggerate the gap between himself and the rest of the animal kingdom. No animal can manufacture aeroplanes, Asdic or radar; but the prize for aeronautics must go to the shearwater which navigated the Atlantic without compass or chart while Asdic has an extremely efficient prototype in the vocal cords and ears of bats. By surrounding themselves with an electric field, some fish (for example, *Gymnarchus*) can—in total darkness—detect foreign objects in the surrounding water with very remarkable precision. The weight of the mechanism involved—including the animal's brain—amounts only to a few grams; a man-made instrument of comparable performance would involve at least a ton of highly complex electronic machinery. In fact, as delicate and precise pieces of machinery, man's inventions have not yet reached the standards of those produced during the natural course of biological evolution. No laboratory in the world can compete with the biochemical skill of even the smallest living organism. On the other hand, man can claim that within a few centuries he has produced things for which Nature required many millions of years; but we need not feel in the least ashamed of the older members of our evolutionary family: we have still a great deal to learn from them.

To visualize man's position in the animal world, it may be useful to define his main diagnostic characters. He is a highly gregarious bipedal mammal with unspecialized limbs but a very large brain. He is the only animal which has developed the symbolisms of speech and writing and he may well be the only animal capable of rational thought. He is, therefore, the only organism which can hand on patterns of acquired learning from one generation to another. To these advantages he owes his dominant position in the world to-day. They have enabled him to exploit his environment and increase his numbers and range of distribution far more quickly and far more extensively than any animal of comparable size. He has eliminated some of his competitors and exploited others for his own use, but the time has now come when different races of men are competing with each other within the closed arena of a limited environment, and it is not easy to see where it will end. There is nothing equivalent to this in the inanimate world; but, when a biologist looks at the general trend of events, he is inclined to say, "Where have I seen something like this before, what is it due to, and how does it *usually* end?"

Of the many points of view from which biologists can study man, three are of particular social interest. First, what is the relationship between the size of a human population and the resources of its environment? Secondly, what are the factors which influence man's ability to acquire new patterns of behaviour? Thirdly, what is the significance of the gregarious habit?

One of the first attempts to subject social problems to biological analysis was made by Malthus in 1789 when he forecast the fate of a nation the rate of increase of which was greater than that of the resources of its environment. Malthus did not say that war, pestilence and famine were inevitable; he said that they were inevitable unless people, by voluntary control, reduced their rate of reproduction. The theory of animal evolution by natural selection, enunciated just a hundred years ago by Darwin and Wallace, involves the principle of over-population and introduces the concept of randomly produced mutations. Some of these increase an individual's chance of survival whereas others decrease it; those which best adapt the animal to the conditions of life imposed by the environment survive, the rest are eliminated. The course of animal evolution is not directed by the organism itself, but by the external environment; the animal throws the dice but the environment decides the winning numbers. A persistent struggle within an over-populated environment is an essential condition for evolution by means of natural selection; it is the price which Nature demands for progress. There is no evidence that adaptations acquired during the life-time of an individual animal can be handed on to its offspring; each generation has to take an environment as it finds it and make its own way in the world. There is also the danger of over-specialization; a species which has become very highly adapted to a particular environment may be extremely vulnerable if the environment changes relatively suddenly. The course of human evolution is entirely different. Speech and writing enable each generation to modify and control its environment in the light of experience gained by its predecessors and to hand on acquired benefits without bodily specialization. As soon as man learns to discipline himself to the fact that his environment is world-wide, he can begin to direct the course of his own evolution without the discomforts of over-population. If he fails to realize his powers and allows things to drift, his future seems dark; if he really bestirs himself, there is much less need to be afraid.

Quite apart from any evolutionary significance, there can be no doubt about the validity of Malthus' argument. Western Europe and North America have followed his advice; but, as stressed by Prof. P. M. S. Blackett[3], the density of population in other parts of the world is far higher than can be adequately sustained by the environment. We can, of course, shrug our biological shoulders and say that different races of men live in different environments and are, therefore, subjected to different intensities of struggle, and it would be comforting if we could be quite certain that it is always the fittest which survive. We cannot salve our consciences quite so easily nor will *we* escape for very long from environmental pressure. Our own population may remain relatively stable, but our environment expands with almost every new major scientific discovery, and the greater the overlap of the environments of different nations the fiercer is the competition. The result is substantially the same as that of an expanding animal population within a limited environment. These problems lie within the field of Section *F* (Economics), but they are fundamentally similar to those which arise in animal ecology; it seems just as unrealistic to regard one race of man as an isolated unit as to study the population of one member of a biological food-chain without reference to those of all the others The writing on the wall is tolerably clear, if man behaves like an animal and allows his population to increase while each nation steadily increases the complexity and range of its environment, Nature will take her course and the law of the jungle prevail

To see this law in action, it is useful to remember that Nature has made, not one but two, great experiments in the design of social animals The first was carried out in Mesozoic times when man's mammalian ancestors were beginning to emerge from reptiles The results of this experiment are represented to-day by the social insects—notably the ants There are a very large number of different species of ants none of which interbreed, among them is found a range of complexity of social behaviour which is not only unique in the animal kingdom but which also forms a very remarkable parallel to different races of human beings At one extreme are species forming small communities, restricted to localized or specialized environments and exhibiting relatively little sub-division of labour between individuals At the other extreme are large and often aggressive communities with marked differentiation of structure between different grades of individuals, populations of this type display high levels of co-operative effort involving, in some cases, the rudiments of agriculture and husbandry In all cases, however, ant societies are organized on a straightforward totalitarian basis, for the contribution made by each individual towards the welfare of the community is determined from the time of birth, each grade of individual is structurally adapted for predetermined tasks How far ants can communicate with each other may be doubtful, but it is tolerably certain that members of the same community recognize each other by a characteristic smell, and as the brain of an ant is about the size of the head of a pin, it is perhaps not surprising that ants should attack or kill an individual from another colony with a smell slightly different to their own It is much less easy to understand why a man, with a brain of an entirely different order of complexity should, at times, react almost equally violently to skin pigments slightly different to his own

But it is not only in respect to individual relationships that the study of ants is relevant to man Ants are the only organisms which—apart from man—indulge in organized warfare, raiding the nests of other species and incorporating captives into their own society But perhaps the most striking facts relate to species which have changed their habits and distribution within recent times Two instances of territorial expansion are known to have occurred in the past 150 years[4] Early in the nineteenth century an Eastern species (*Pheidole megacephala*), having spread rapidly over North Africa and South Europe, managed to reach the islands of Madeira and Bermuda, in both places it exterminated the smaller native races Meanwhile, a similar policy had been carried out by another species (*Iridomyrmex humilis*) from the Argentine which, having landed at New Orleans, very rapidly overran the southern United States, in due course it too reached Bermuda, where it proceeded to eliminate *Pheidole* In the world of ants there is no place for small peaceful communities unless they can isolate themselves effectively from larger and more powerful neighbours, nor does there seem any lasting peace between large aggressive communities Solomon's advice has, I suspect, been misinterpreted It should read "Consider the ants, and, if you use your intelligence, you will see how *not* to deal with international problems'

Having designed the ants, Nature waited for about 150 million years before embarking on her second or human experiment She waited, in fact, until it could be carried out with a species in which an individual's contribution to society was no longer based on inherited structural characters but on the power of intercommunication with other individuals, in other words, until man's brain had reached a level of development which enabled him to control his environment, and to deal rationally with the subdivision of labour between individuals and with the distribution of natural resources between different groups of individuals At the same time she arranged that such groups should not be physiologically isolated from each other Different races of men can interbreed or they can, if they wish, come to mutual agreement about the distribution of world resources between different nations The first policy would seem to lead to a World State with uniformity of social pattern and of material interests, the second policy involves territorial limitations and economic agreements Both, as we know only too well, involve great practical difficulties All the same, men really ought to be able to do something better than ants

The second basis of comparison between man and animals concerns the factors which control his behaviour The past fifty years have produced a very great increase in our knowledge of animal behaviour and about the factors which control the acquisition of new patterns of response For present purposes, however, attention may be focused on two problems, the extent to which animals can profit from extraneous instruction, and the extent to which they are able to learn for themselves The first of these fields is explored by means of the conditioned reflex technique, whereby an animal learns to associate a specific visual, or other sensory, stimulus with forthcoming food or impending danger In order to establish this result it is necessary to conform with five basic principles, all of which have their counterpart in the training of human beings

(i) The response expected from the animal must not be unduly complex, the animal must be able to reach the food or escape the danger by making reasonably simple movements In other words, the problem must not be too difficult (ii) The lesson must be presented to the animal under conditions which ensure freedom from extraneous disturbance It will not learn if its attention is constantly diverted by other changes in its environment (iii) The problem must be presented to the animal on an adequate number of occasions, the more frequent the lesson, the fewer the mistakes become (iv) There must be an 'incentive' to learn—a 'reward' for success or a punishment for failure Further, the 'reward' must be related to the needs of the animal (v) Finally, the experimenter must possess adequate skill and patience The ability of an animal to learn depends to a very large extent on the personality and enthusiasm of the teacher

These five principles apply equally well to the education of human beings if we make suitable allowances for increase in complexity of the lesson to be learned and in the nature of the incentive to learn But we can go a little further for, as with men, different individuals of the same animal species learn at very different rates On the other hand, there does not seem to be any clear correlation between an animal's ability to learn and its position on the evolutionary tree It is possible to trace the structural evolution of the human brain through each of the main classes of vertebrate animals , the large paired hemispheres arose in the Devonian lung-fishes and the cerebral cortex in the early Permian reptiles It would be very convenient if step by step with an increase in size and complexity of the brain it were possible to trace a corresponding increase in complexity of behaviour and in ability to learn Unfortunately this is not the case , some fish, without hemispheres or cortex, exhibit behaviour patterns which seem just as complex as those of reptiles or even of some mammals In due course this difficulty will be resolved but for the time being one can only say that there seems to be one feature common to all species which learn easily, namely, a vivacious but not unduly excitable temperament—fish, rats, monkeys and children are all interested in their surroundings, they have a natural tendency to explore their environment and they are interested in anything new or strange , they are all, perhaps, potentially good scientific observers

But the value of the instruction given to human beings by a teacher is largely judged by the extent to which it enables a pupil to make use of his acquired knowledge and to go on to learn more by himself Within the animal world there is very little evidence to suggest that experience acquired from one pattern of environment or from one problem can be readily applied to subsequent ones of somewhat different nature An animal's own approach to a problem, like that of a very young child, is very largely one of random exploration , having found the solution by chance the number of ineffective responses on future occasions becomes less and less until the correct response is stabilized

How far animals display evidence of the higher levels of mental analysis associated with 'intelligence' in human beings is not too clear, for it is extremely difficult to subject intelligence to an agreed standard of measurement When judged by human standards, the I Q 's of all animals are, undoubtedly, very low , but it may be that we are not always setting *them* quite the right type of examination

Although it is difficult to detect an increasing capacity to learn with an increase in size and complexity of the brain throughout the main classes of vertebrates, it seems clear that there is a substantial increase in learning ability as soon as an animal's brain reaches a level of structural complexity comparable with that of man The young chimpanzee, like a human baby, is typically a friendly playful creature dependent on, and with an affection for, its mother But as it grows up, it begins to show marked signs of individuality , some become morose, unfriendly and vicious, others retain a friendly disposition towards their neighbours and a co-operative attitude towards human teachers The ability to respond to training shown by the latter type of individual is, of course, very remarkable , but when left to itself, a chimpanzee seems to rely on an initial process of trial and error Like many other mammals, it can give audible and visible signs of fear, anger or pain , but there is no evidence that a chimpanzee can make audible or visible signs which other individuals associate with specific material objects , the mental development of the adult ape seems roughly equivalent to that of a human baby before the latter has learnt to speak Nothing can disguise the enormous difference between an adult ape and an adult man in ability to learn and to control their environments, but it might be argued that a relative test of the brains of an adult ape and of an adult man, as computing instruments, should be conducted on the basis that neither pupil nor teacher should be allowed to speak, read or write , the gap between animals and men might narrow very appreciably

The third and perhaps most important biological aspect of man's behaviour concerns the gregarious habit Here again the distribution among vertebrate animals is curiously unrelated to their evolutionary history , it is well marked in certain species of fish, birds and mammals, but absent in others In some cases the existence of a herd or flock is clearly of survival value , a pack of wolves has a wider choice of food than an individual operating by itself But, it is not always clear why one species should be more gregarious than another to which it is closely related In the present state of knowledge, it may be safer to say that some animals are restless or uneasy unless in close proximity to individuals of the same species—that they have, in fact, a deep-rooted antipathy to isolation or loneliness The resultant grouping establishes the herd as a unit which responds as a whole to an external stimulus applied to one or a few individuals The response is most clearly defined when the stimulus evokes an emotional reaction of fear or anger in the individuals directly concerned, and one of the most distinctive features of herd behaviour is the speed at which these emotions spread throughout the community If certain individuals are more highly susceptible than others to external stimuli, the response of the group is determined by the most timorous or the most belligerent members of the community The majority of the herd subjugate their own individual behaviour to that of a few, and in the long run individuals benefit by greater security from predators or greater certainty of obtaining food If an individual is unduly insensitive to emotional stimulation by its neighbours, it is likely to be eliminated by natural selection—the sheep that walks by itself gets eaten and the solitary wolf may starve These principles were applied to the analysis of human behaviour by Wilfrid Trotter[5] In order to avoid physical or mental isolation, men are prepared to subjugate their own immediate needs or predilections to those of society as a whole Anti-social activity is kept in check by fear of intellectual or physical isolation , feelings of increased security and greater freedom from personal doubts and fears are set off against loss of individual freedom of action How far psychologists have developed or rejected Trotter's suggestions I do not know, but there can be little doubt that they opened up a useful biological approach to sociology by suggesting that our instinctive reaction to something new or strange is, as in animals, to conform with our neighbours, and that, at moments of crisis, it is better to follow a leader than rely on personal judgments These and allied problems belong to Section *J* (Psychology). All I wish to stress is that the phenomena of mass psychology in man, like other aspects of his behaviour, have their roots far down in his evolutionary history

Perhaps the most striking difference between the social habits of man and those of animals is the existence of a hierarchy or grading within human society Only in a very few cases does this appear to exist within the animal kingdom The nearest approach seems to occur in birds; a flock of jackdaws feeding in a restricted area resolves itself into a well-marked order of feeding priority. Lorentz has recently reported that if a high-ranking male decides to mate with a low-ranking female, the latter rises in social status and feeds with her husband; all this sounds reasonably familiar to human ears.

This is perhaps as far as a zoologist ought to go in trying to view mankind through biological spectacles. But one does not need to be a professional biologist to appreciate that the rates of change in the pattern of human behaviour and in the nature of our environment have, during the past five thousand years, been incomparably greater than those of any other organism at any period of its history; our clothes, houses, habits and social organization change with successive generations. In fact, if one were forced to select the organism which best displays the phenomenon of persistent evolution one would undoubtedly choose man. I have tried to show that the broad principles which relate the size of human populations to the resources of their environments and those which govern an individual's ability to learn from personal experience and so adapt himself to his environment are qualitatively similar to those which apply to animals. On the other hand, man is—as I have said—unique in that he is—or can be—the master and not the slave of his environment, and the story of his later evolution is told in terms of social and economic history.

In suggesting further points at which biological principles seem to be applicable to the evolution of human society a zoologist can only look towards Section *H* (Archæology and Anthropology) and hope that his spectacles are not completely out of focus. In its very early stages human society must have been organized into quite small units each dependent on the natural resources of a small circumscribed environment. The discovery of fire and development of agriculture must have increased the range of the environment and the optimum size of the population required for its exploitation, while the stability of the group would become more and more dependent on the maintenance of an effective sub-division of labour. The larger the population and the greater the degree of specialization the greater the limitations necessarily imposed on individual freedom of action. A new and very important integrating factor seems to have come into action when natural phenomena became linked with supernatural concepts—fear of isolation or reprisals from fellow-men being reinforced by fear of a superhuman agency and a sense of greater security inspired by reliance on supernatural support. Such beliefs had no material basis but they would be the cement which held society together and, as such, be of immense survival value. But it is difficult to avoid the conclusion that such beliefs, like scientific theories, must undergo change as man's knowledge increases and his environment alters. From this point of view, it is not easy to regard any one belief as an expression of absolute and unchanging truth. It may be argued that such things lie outside the orbit of the British Association; but if science is to be of direct cultural significance, it cannot shut itself off from one of the main factors which have influenced men's attitude to social problems. A recent issue of *Nature*[6] contained a leading article on the proceedings of the last Lambeth Conference; it must have been a very long time since an Archbishop of York addressed such a Conference in language which scientists could so readily understand. Against such a background, the sciences and the humanities ought to be able to find something in common.

III

It is easy to say that science should be welded to the humanities, but much less easy to suggest how this should be done. Each of us has different views according to his own particular interests. I confess that my own approach is based on personal experience. About fifty years ago I chose to specialize in biology, and from time to time I have been asked, "If you had known that you would spend a good deal of your later life studying the movements of animals, what subject apart from biology would you have read at school and at the University?" The answer is simple. I would have read physics, chemistry, mathematics and mechanical engineering. The moral is that no young scientist should be allowed to forget that new discoveries tend to arise from the borderland between different subjects where the discipline of one is applied to another. Had I appreciated this I would have been a much better biologist; but whether I would have been a better human being is another matter. If I am asked the 64-thousand dollar question, "Had you known that you would have had to adjust yourself to a rapidly changing and somewhat uneasy world, what additional training would you like to have had?" I think my answer would be that I would like to have been trained to think dispassionately about social and political affairs in the light of experience drawn from the past, and to have been taught to appreciate beautiful things. But could I have acquired this knowledge while training as a scientist? Perhaps not, but I still think that I could have been shown a wider picture. Having been taught to visualize the spectrum in terms of the wave-lengths of light, could not I have been encouraged to learn a little about colour as a source of æsthetic pleasure? Why did I learn about the properties of iron and carbon without reference to the industrial revolution? I might even have developed a taste for the classics if I had known that Aristotle had written a very good text-book of zoology. Perhaps I expected too much in hoping to appreciate an artist's view of Nature from the point of view of the scientist. But I am not completely convinced. A scientist's attitude towards his observations does not seem to me to be so very different from that of a poet towards his words or a painter towards his colours; isolated observations have no more value than single words; it is only when they fit into a satisfying pattern that the scientist feels he has achieved his end. This analogy may be unconvincing, and if it still seems difficult to combine the vision of the artist with the outlook of a scientist, I can only suggest that Leonardo da Vinci and Sir Christopher Wren seem to have had pretty good shots at it. It would be very interesting to know the sort of training they had in early life.

But a plea for a wider outlook in the teaching of science is nothing new. It was largely the background against which Section *L* (Education) came into being, and it was urged again and again by Sir Richard Gregory. Since then there has been much discussion and many reports. In 1933 the declared aim of the London County Council was that they "wished their pupils to obtain a broad view of nature, to study Mankind and his environment from various standpoints, more particularly from the point of view of both the biological and physical Sciences". In 1946 the Advisory Council for

Secondary Education in Scotland was even more explicit "During the earlier secondary years at least, the study of man in his world, like the study of science, is a unity which should not be broken by any sharp division into 'subjects' the theme must be one' Only last year (1958) a Committee of the Science Masters' Association urged that "The schools have the duty of presenting Science as part of our common cultural and humanistic heritage, it should be taught in harmony with and not in opposition to the various Arts subjects " It seems fair to assume that this is a goal towards which we would all wish to strive, but when we try to approach it the road proves extremely hard and most of us, in practice, fall by the wayside

We cannot shut our eyes to the fact that our national economy depends on our ability to make and exploit new scientific discoveries If we wish to maintain or extend our standards of material comfort, we must have more professional scientists and highly trained technicians, and we must be prepared to devote an adequate fraction of our educational effort to get them But highly trained specialists form only a very small proportion of the population, and we may be paying for them in very hard currency if we have to deny to a very much larger fraction of the community a reasonable chance of "seeing life steadily and as a whole" A democratic society has to decide how much of its total educational effort should be devoted to an ever-increasing standard of living, and how much to raising the intellectual standards whereby the majority of the population forms its judgments on matters which are susceptible to personal prejudice or political propaganda It is not easy to assess the factors which mould public opinion, but a recent inquiry sponsored by the Nuffield Foundation[7] and the B B C indicates relatively clearly that the attitude of mind of an individual towards a changing environment is directly related to the nature and extent of his full-time education and that it is this training which largely determines, in later life, his response to other potential sources of education—such as libraries and broadcasts If we wish to awaken a widespread interest in science, or—still more—wish to contribute toward the formation of an enlightened public opinion, we must sow our seeds in the schools and in organized centres of adult education In the latter field, the Area Organizations of the British Association are of fundamental importance as authoritative and coherent sources of information for an increasing fraction of the community By working with other organizations they can make a very definite impact not only on the scientific but also on all aspects of public opinion

But the key to the main problem lies in the schools, and the responsibility resting on school teachers can scarcely be exaggerated[8] Too many are asked to do two jobs at once—to provide a training for potential specialists, and at the same time give a training which will best equip the average boy or girl for later life If we are to pay more than lip service to the belief that a good all-round education is the best means of raising the intellectual level of the community, we must recognize that our most urgent need is for good general practitioners in the art of education Really inspired teachers working with adequate but simple equipment will achieve more for general education than specialists in highly equipped laboratories But the scales have been heavily weighted in favour of specialization Almost exclusively, our universities are producing specialists Some of these return to the schools, where they in turn teach on a specialized front So the spiral of specialization has gone on It is only natural that able teachers should get an intellectual stimulus by preparing boys and girls for scholarship examinations and so providing recruits for fields of research in which they themselves are interested, but it is by no means clear that their work is necessarily more important, or more difficult, than that of those whose primary object is to persuade people that they cannot live by bread alone If we really believe in general education, we must produce and encourage the right type of teacher No man or woman in their senses enters the school-teaching profession for financial gain, but a community which rates thirty inspired schoolteachers as equivalent to one high-grade comedian or film star may well deserve a very unhappy fate A benevolent dictator would make school-teaching the most highly respected and the most highly paid of all professions, and the Ministers of Education the most important officers of government, but, in both cases, he would demand a very high level of performance We must do the best we can without him

The value of an educational system can perhaps be judged by the extent to which it leaves people with a desire to know more about the world at large and a feeling that this can be satisfied, at least in part, by personal effort To meet a constantly changing environment the general pattern of teaching must be constantly under review If a curriculum is allowed to degenerate into a series of isolated subjects with little or no immediate bearing on everyday life, the result can, perhaps, best be described in words which I think the president of Section *L* (Education) will recognize "When far too many boys and girls will carry away from school little more than gobbets of ill-digested knowledge and a distaste for what has yielded so little"[9]

But, as I have said, it is easy to talk and to criticize, it is much harder to plan for action So far as science is concerned, the British Association might approach the problem of general education in the three familiar stages of research, development and production The first step would involve an assessment of the evidence · if the Association's judgment were given in favour of a wider, and perhaps more biological, outlook on education, it should do all it can to see that it is put into practice on a limited front and—in the light of experience—allowed to spread gradually into full-scale production All this would involve very far-reaching reorganization of schools and universities While Oxford and Cambridge shiver on the brink of optional Latin, the University College of North Staffordshire is swimming the Hellespont by insisting that all students should, during their first year, survey the whole field of knowledge as a coherent picture before proceeding in three subsequent years to specialized training This is, in my opinion, one of the most important and courageous educational experiments in our times for, if it succeeds, a great number of our major difficulties will be resolved

On the other hand, if 'general education' and 'general science' are condemned as 'smatterings of everything and a knowledge of nothing', and if the concept of a central theme around which all parts of a syllabus would revolve be found to be illusory, it is high time we stopped talking about the broad cultural value of science and concentrated our efforts on widening the interests of specialists during or after their technical training. Much can be done by relatively formal teaching, but—if I may judge from personal experience—more depends on the extent to which students are given the time and opportunity to educate themselves by contact with men and women with entirely different interests and outlook from themselves. This is the great strength of the older residential universities; but here again, they may have something to learn from North Staffordshire.

But the older we get the less inclined we are to go back to school. If we want every member of the population to keep in touch with what is going on in the scientific world and to realize its impact on their lives, we must rely on the Press and on the broadcasting authorities. Neither of these is primarily an educational medium; in both cases the main objective is to put science across in a form that readers and listeners find interesting. In respect to music, the B.B.C. has been outstandingly successful; other fields of broadcasting may be less amenable, and it is not altogether easy to know how far an increase in factual knowledge concerning a number of isolated fields of science enables listeners to appreciate the broad social and international implications of science as a whole.

But when all is said and done, science can only play its full part in furthering the welfare of mankind if it is used at a very early stage of education, as a means of encouraging a dispassionate but optimistic attitude towards all aspects of human affairs. To move from national traditions and aspirations to others based on international welfare may prove less painful if we are prepared to look on man and all his problems as a phase in the evolution of the universe and if we have the courage to believe and to teach that he can, by means of his intellect, control and direct his own evolution and destiny.

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[1] See Blackett, P. M. S., *Advancement of Science*, 15, 367 (1959).

[2] Presidential address to the British Association (1952).

[3] Presidential address to the British Association (Dublin, 1957).

[4] Haskins, C. P., "Of Ants and Men" (1945).

[5] "The Herd Instinct in Peace and War".

[6] *Nature*, 182, 965 (1958).

[7] Thirteenth Report of the Nuffield Foundation, 66 (1958).

[8] Proc. B.A. Conference "Science in Schools" (1958).

[9] Report of the Advisory Council for Secondary Education in Scotland, 25 (1946).

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

THE VISUALIZATION OF MAGNETIC PROCESSES

IN delivering the presidential address to Section *A* (Mathematics and Physics), Prof. L. F. Bates prefaces his remarks with a brief outline of the ferromagnetic domain concept. He then describes the several ways in which the boundaries and surfaces of such domains in single crystal and in polycrystalline materials may be manifested. He shows how the original Bitter figure technique has given results of great value concerning main domain and closure domain configurations; it has provided considerable support for the ideas of Néel and others as applied to the magnetization processes which occur when single crystal specimens of appropriate shape are exposed to magnetizing fields, and has given visual proof of the important effects of inclusions, defects and strains on magnetization phenomena.

The technique has recently been much extended first by Craik's development of a detachable colloid film carrying with it a record of domain configuration, which can be examined optically and also in a commercial form of electron microscope. Craik and Griffiths have shown that the film technique can be successfully used to examine fine domain structures on ferrite surfaces prepared by the simple cleavage of single crystal specimens. By using films of ever-decreasing colloid concentration, Craik found the minimum thickness of a continuous deposit above a 180°-domain wall on a cobalt crystal to be 10^{-5} cm.

The colloid film techniques restrict the experiments to static observation and to limited ranges of temperature, and recently attempts have been made to develop dynamic methods. Perhaps the most successful is the polarized-light technique of Lee, Callaby and Lynch, which has been applied to the motion of a domain wall in a thin sheet of polycrystalline 'Perminvar', an alloy of approximate constitution $Ni_{45}Fe_{30}Co_{25}$, which has been magnetically annealed by cooling it in a magnetic field. Davis has followed the motion of such a wall by pick-up in a search coil wound on the specimen. Lee, Callaby and Lynch have used the transverse Kerr effect. The specimen is illuminated by a beam of plane polarized light, which forms a small strip on the specimen surface, roughly parallel to the wall, and which acts as a light probe. The reflected light is collected by a microscope, passes through a 'Polaroid' and is thrown upon the cathode of a photomultiplier. As a domain wall moves across the beam, the intensity of the collected light changes, the change being made periodic by the application of a weak alternating field to the specimen. The current from the photomultiplier is amplified and a signal displayed on a cathode-ray oscillograph. By using two light probes a domain wall can be made to move through each in turn, so that the velocity of wall movement can be followed. It is found that the velocity is fixed almost entirely by the eddy currents in the specimen.

An electron microscope has been directly applied by M. Blackman and others to examine the stray fields at the edges of ferromagnetic specimens, and in this way it has been shown that the domains in hematite are unexpectedly large. Spivak and his collaborators in Moscow have obtained direct photographs using the secondary electrons released by a primary beam on the specimen surface. They have also used an electron mirror method. Kaćzer, in Prague, has used a thin 'Permalloy' probe vibrating above the surface of a specimen to map domains. However, all these methods have to date been less informative than the colloid method, and may more readily manifest surface imperfections and inhomogeneities than domain walls, but they may, of course, be greatly improved in future.

MEDICAL ASPECTS OF COMPLEX CARBOHYDRATES

PROF M STACEY points out in his presidential address to Section *B* (Chemistry) that carbohydrates play an essential part in the vital processes of all living cells Their simplest forms, the monosaccharides, are synthesized from carbon dioxide and water in the leaves of living plants by the agency of sunlight and chlorophyll The chemistry of these photosynthetic processes, including sugar interconversions, phosphate transfer and the enzymes involved therein, is now being worked out Likewise, the mechanisms of the build-up and breakdown of the complex carbohydrates, the polysaccharides, is now well established

Microbial and animal cells, devoid of photosynthetic pigments, must use the simple sugars as material and energy sources for their own metabolic cycles The proper carrying out of these cycles is necessary for the healthy condition of every living cell, and in the animal the blood sugar (glucose) balance must always be maintained For the growth and reproduction of cells and tissue, complex polysaccharides must be built up, for example, to form cell membranes, structure and storage material and colloidal fluids, while the pentose sugars form a part of the genes and chromosomes

Some of the important processes in which both simple and complex carbohydrates are involved are discussed by Prof Stacey

(*a*) *General metabolic processes* These involve digestion of foods and the absorption of glucose and other sugars , they involve the metabolic cycles and the function of enzymes concerned with them They concern the synthesis and breakdown of glycogen, the conversion of sugar to fat, the biochemistry of muscle action, formation of milk, etc The hormones insulin and epinephrine are involved in glycolysis The great medical value of insulin in controlling diabetic conditions is well known In this field synthetic substitutes for use in diabetes are being actively studied

(*b*) *Detoxication mechanisms* Frequently the body needs to get rid of excess toxic substances such as drugs, and it can do this by oxidation processes, coupling up with the sugar acid D-glucuronic acid and then excreting the complex D-Glucuronic acid is an important tissue component

(*c*) *Structural components of the body* It is with these substances that we can expect to see great advances in the future, for complex carbohydrates known as mucoproteins and mucopolysaccharides form a large part of components such as bone and cartilage tissue, cell membranes, connective tissue, skin and its ground substance, joint fluids, synovial fluid, eye tissues and fluids, gastric and intestinal mucosa, etc

These complex polysaccharides have as their building units nitrogen-containing or 'amino'-sugars, hexuronic acids and hexoses, and often, too, acetyl and sulphate residues are present Associated with the carbohydrate protein complexes is a novel group of 'nine-carbon' sugars, the nonulosaminic acids, known as sialic and neuraminic acids Detailed work on the chemistry and biological importance of these acids is not yet well advanced Generally, the mucopolysaccharides are concerned with movement of parts of the animal body and thus are important in conditions of arthritis, rheumatism, etc , and with general ageing processes

(*d*) *Blood components* Many components of blood contain complex carbohydrates , the red cell surface contains mucoproteins, white cells contain nucleic acids, while serum contains a wide range of muco-substances

Furthermore, many tissues and fluids of the body such as gastric mucosa, saliva, etc , contain the so-called blood-group factors, which are polysaccharide–amino-acid complexes One of the most important medical developments has been with blood plasma substitutes, where the bacterial polysaccharide dextran has become established as an excellent expander of blood volume The clotting of blood in the body is inhibited by heparin, a complex polysaccharide sulphate, the action of which can be imitated by other polysaccharide sulphates

(*e*) In many other directions carbohydrates are becoming of increasing importance In the antibiotic field, streptomycin is an important complex carbohydrate, while many others such as puromycin, magnamycin and kanamycin contain amino-sugars

In disease-producing agents, the complex surface carbohydrates play a significant part in immunity studies, and there is a close relationship between carbohydrate structure and immunological specificity Pyrogens or fever-producing agents from bacteria are also carbohydrates Muco-substances and the enzymes which destroy them are important in fertilization processes, but little is known at present about the carbohydrates of eggs

A new branch of carbohydrate chemistry is developing in the virus field, and the necrosis of some tumours by bacterial polysaccharides has yet to be studied in detail

RECENT DEVELOPMENTS AND TRENDS IN PALÆONTOLOGY

THE past two or three decades have witnessed a remarkable increase in the output of palæontological research Most of this has been of a purely descriptive character, often related to the needs of the stratigraphical palæontologist, but much has been of more general interest, particularly in the borderline fields of taxonomy and evolutionary theory Prof O M B Bulman attempts in his presidential address to Section *C* (Geology) to give a non-technical account of palæontological activities in some of these directions

Chance plays a large part in the preservation and discovery of fossils, and modes of preservation limit the techniques which can be applied Hence from the nature of his material, the palæontologist has less freedom than the neontologist in planning his research, and is often unable to follow some otherwise desirable line of investigation New material is, however, constantly being obtained, and the scale on which effective techniques are being devised and applied is a distinctive feature of modern palæontology Particularly characteristic of the immediately post-war years also have been the many attempts at constructive syntheses of palæontology and allied sciences

Palæontology provides a general and imperfect, though steadily improving, record of most groups of organisms, and in supplying a few true evolutionary series it has given a fourth dimension to the concept of the species Applying the results of absolute rather than merely relative dating of rocks, it is beginning to contribute some tentative calculations of evolutionary rates in various groups, particularly among vertebrate animals , and the establishment wherever possible of invertebrate phylogenies will have rewarding results here as in other fields The problem of evolutionary mechanism is a purely zoological one, but the ultimate proof or disproof of evolutionary theories involving phylogeny, such as proterogenesis, recapitulation and orthogenesis, also lies fairly within the field of palæontology

The major contributions in palæontology have been made where its limitations have been frankly recognized and its unique assets most fully exploited These are, of course, the time factor and the historical record of evolution To bring palæontological evidence into the evolutionary picture, however, involves a synthesis with genetics, taxonomy and zoology from which is now emerging a new 'science of four-dimensional biology' In such studies, the emphasis has tended to shift from the individual to the population, with the consequent need for statistical treatment, and successful generalizations will call for accurate quantitative as well as qualitative methods of research , but Prof Bulman emphasizes in this address the primary importance of the most detailed and exact morphological investigations which contemporary techniques can provide

MAN AND THE WORLD'S FAUNA

DR L HARRISON MATTHEWS, in his presidential address to Section *D* (Zoology), points out that man has continually preyed on the fauna of the world The increase in the human population and man's technical skills have enabled him to exploit the fauna with ever-increasing destructiveness It was not until the populations of animals were reduced below the danger point that man realized that they were not inexhaustible Destruction of particular species has also been due to man's destruction of the environments to which the fauna has been adapted Human settlement of land and the development of agriculture have caused many animals to be banished from their natural environments

Man now realizes that breeding fauna in captivity will not alone maintain its existence He has introduced legislation prohibiting or limiting the killing of certain species and has provided sanctuaries in the form of reserves It is essential, however, that the conservation be not only applied to the fauna but also to the environments Basically, it is a problem of land management and development, vital to man as a means of producing energy—food and other useful products

For the conservation of animals specifically for commercial purposes, Dr Harrison Matthews gives examples of the recoveries for the fur-seal and the elephant-seal, and how extinction in the Antarctic was prevented by the intervention of the Falkland Islands Government He also mentions the not so satisfactory history of the whaling industry , the only thing that regulations gained here was to reduce the rate of extermination In general, the sea-fishing industries of the world present many complications so far as conservation is concerned, especially the question of replacement of the life-giving plankton On land, over-grazing is often a serious threat to animals , however, some scientists hold the theory that in some cases artificial control is unnecessary, stating that it is effected by natural causes in the long run

Dr Harrison Matthews refers to the population dynamics of certain classes of mammals, and gives an account of the catastrophic 'crash' that invariably arrives after a peak in numbers has been reached, especially in vole-plagues. The over-crowding of the immediate environment that occurs tends to result in psychological tension which eventually causes dysfunction of the adrenal gland , the breakdown of adrenal function causes the rapid death of the animals

A recent inquiry shows that in 1958 the world population increased by 47 millions , at this rate, in forty years time the human population would double It is unlikely, however, that this will occur as the growth of the human population tends to become slower and reach a stable level with the increasing standards of living If we compare the present build-up of population with the cyclic build-up of the population of small mammals, it would seem that we are rapidly approaching the peak and the catastrophic 'crash' Other factors are also likely to control the growth of population, such as atomic war and its radioactive contamination of the atmosphere, social control by inhibiting fertility in either sex, or the emergence of new epidemic diseases

Dr Harrison Matthews points out that the conservation of the world's fauna must be planned on a world-wide scale It must be decided what parts are to be developed for human occupation and what parts are suitable for conserving fauna , already a number of national and international bodies interested in conservation exist , however, as such there has been only little action He sums up by advising all zoologists to study any aspects of biology of the larger animals before it is too late

TRENDS IN URBAN EXPANSION

LARGE-SCALE urban growth, which was a feature of nineteenth-century industrial development in western Europe and eastern North America, is the theme of the presidential address to Section *E* (Geography) by Prof K C Edwards It has continued to the present day, affecting almost all parts of the inhabited world Recent decades, however, have witnessed a sharp acceleration of the process and urban expansion is now going on at an unprecedented rate While industrialization remains a primary factor, it has come to play a relatively less important part in the crowding of people into cities

Owing to the lack of a common definition among different countries as to what constitutes an urban population, precise measurement of the rate of urban growth for the world as a whole is impracticable Some idea of its magnitude over the past half-century so far as large towns are concerned, that is, those of 100,000 inhabitants or more, can be obtained from the figures in Table 1

Table 1

	No of towns of 100,000 inhab or more	Size groups (population in thousands)				
		100-250	250–500	500–750	750-1,000	More than 1 million
1910–13	322	200	63	33	8	18
1950–53	1,071	611	299	67	32	62

Not only has the number of large towns more than trebled, but also a marked upward trend in their mean size has occurred The most spectacular evidence of urban growth is afforded by the millionaire cities There are now about ninety of these vast agglomerations, of which London and Paris were the only examples a century ago, and their number increases yearly Some 200 million people now live in these huge cities, and the day is not far off when they will shelter one-tenth of all mankind

Yet the mammoth cities and existing conurbations do not represent the ultimate stage in the process of urban accretion, for in certain instances groups of these tend to coalesce, forming vast continuous urban areas to which the term 'megalopolis' has been given The outstanding example is the virtually continuous urban belt stretching for 400 miles from Boston to Washington, D C containing more than 30 million people

Whether in the older regions of settlement or in those of newer development, the expansion of cities is mainly due to the movement of people from rural areas and from the smaller to the larger towns The townward drift is primarily the expression of a desire for improved conditions of life In the process no new equilibrium between rural and urban populations is discernible, for food production, despite a dwindling labour force (except in south-east Asia), is increasingly dependent upon technical advances in agriculture To-day the essential relationship is that between urban demands and agricultural productivity

The latest phase of urban expansion has had significant effects upon the individual city The rising importance of service functions of all kinds has substantially altered the structure of urban employment, the growth of administrative and other non-productive activities has intensified the use of the central business quarter, the demand for office accommodation in particular has increased the pressure on building sites, leading to an acceptance of the tall building for such purposes, often in defiance of tradition, retail services have become hampered through traffic congestion and competition for space, resulting in an increased emphasis upon secondary shopping centres in residential districts In connexion with these and other changes, the controlling factor is motor transport Its effects are both centrifugal and centripetal, and the capacity of the city to discharge its functions satisfactorily will increasingly depend upon the solution of problems to which this form of transport gives rise

HOW MUCH SCIENCE ?

THE recent campaign in Great Britain for increasing the proportion of our human and material resources engaged in science, in all its forms, has been supported by a wide range of arguments, some of which are of doubtful validity What tests can be applied to determine if and when there is a shortage of scientists ? It is with this question that Prof J Jewkes commences his presidential address to Section *F* (Economics) To the economist the term 'shortage' has an exact meaning There is a shortage when, at the existing price, the demand is greater than the supply Although the evidence is scrappy, the indications are that there is no shortage of scientists, in this specific sense, in Great Britain at present For the salaries of scientists are not at a level nor moving in a direction which suggests shortage, nor do the latest estimates of probable supply and demand indicate any serious gap between the two

It is frequently suggested that there is, nevertheless, an 'unmet need', implying that those who exercise the demand for scientists are not sufficiently conscious of their value to the community Unmet need is an elusive concept, but four reasons have been given for believing that it exists First, it is said that Britain is lagging behind the United States and the United States behind the U S S R These international comparisons, when they include the U S S R, are for the most part hazardous statistical exercises with non-comparable material Even in the comparisons between Great Britain and the United States many obstacles exist, both as to method and materials It seems to be a reasonable assumption, however, that having regard to their populations, there is no great disparity between the two countries Secondly, efforts have been made to establish correlations between the rate of change of industrial output and of the number of scientists and technologists in industry But the statistical material employed here and the deductions based on it both seem to be unsatisfactory Thirdly, it is sometimes suggested that since some industries spend on research and development relatively more than others, this proves that the second group is lagging Fourthly, attempts have been made to measure the net gains arising out of expenditure on research and development, the results obtained in this way are interesting but do not support any very spectacular conclusions

The scale of scientific activities in the community is determined by a very puzzling combination of public and private views, public and private actions and, in the last resort, the striking of the right balance will inevitably be a matter of informed guesswork and of intuition At the moment the final judgment is probably being distorted by the tendency to exaggerate the part that science has played in raising the standard of living in the past, to overstress the potential material benefits of the more spectacular recent scientific discoveries, and to belittle the contribution made to economic expansion by skills and capacities non-scientific in character

THE CRITICAL IMPORTANCE OF TRANSPORT AND COMMUNICATIONS

IN the modern world, transport affects the citizen and the engineer at every turn In Britain, about 25 per cent of the gross national product is accounted for by transport and communications Not only is the modern State utterly dependent for its daily bread on transport, but also its competitive power depends largely on its efficiency in operation Moreover, it is one of the most easily observed aspects of a country's organization and achievement, and it has a psychological as well as a material impact The subject bristles with technical, economic and political problems, but the aim of Sir Ewart Smith's presidential address to Section *G* (Engineering) is to express some very general thoughts as a challenge to our sense of urgency

In the mid-nineteenth century, Britain had the best transport system in the world, this was largely the creation of engineers, who not only invented, designed and constructed in the technical sense but also often organized the business sides of the ventures they had conceived When, to-day, we compare land transport at home and abroad, we must admit that we have not applied either the technology or the money necessary to keep up with the general advance

Although very recent years have seen some awakening of Britain to its transport needs, a few facts and figures may be mentioned to underline the need for still greater boldness in plans and expenditure

The projected expenditure of £60 million on new roads and major improvements is no more than the 1939 rate, allowing for the fall in the value of money, though the number of vehicles has grown from 3 to more than 7 million, and is increasing at 8 per cent a year While attention is now being paid to motorways, by the end of 1959 only 64 miles will be in use, whereas between 1830 and 1850 new railway routes were being built in Britain at an average rate of 320 miles a year Urban road development lags even more We have no established centre for training high-grade traffic engineers, although the savings to be gained from traffic engineering are immense An increase of only 5 m p h in average speeds—at present 20 m p h in urban districts and 32 m p h in rural—would give an economic saving of at least £180 million a year, and much more as traffic grows

The railways, too, suffer greatly from past neglect of capital expenditure and technical recruitment During 1900–55 true capital outlays were very small, and as late as 1956 only 0 23 per cent of the employees of the British Transport Commission were qualified scientists or engineers In comparison, in the National Coal Board the proportion was 0 7 per cent, in the Central Electricity Authority 2 9 per cent, and in the Atomic Energy Authority 10 9 per cent The British Transport Commission is making valiant efforts to retrieve the position, and the results are likely to be striking Nevertheless, even bolder thinking is desirable, particularly in regard to size of wagons and turn-round (wagons now average only 10 miles/day) It must be stressed that in this the users have major responsibilities as well as corresponding opportunities of gain

In transport abroad, and in our newer and progressive industries, scientific engineers play a much larger part than in the road and rail transport organizations of Britain , we need to train more and use them more widely We must remedy the defects in the transport system of Britain, particularly on the roads, by far greater capital expenditure and by a bolder approach to the technical and organizational problems involved

ARTIFICIAL ORGANS : BIOLOGICAL APPLICATIONS

WE are reminded by Prof A Hemingway, in his presidential address to Section *I* (Physiology and Biochemistry), how much the study of isolated organs and tissues maintained under conditions ensuring survival has yielded to the physiologist These tissues are immersed in, or superfused (a new technique), or perfused with blood, serum or solutions which may be regarded as 'artificial bloods' A solution in which the ionic concentrations of sodium, potassium and calcium were adjusted to maintain conduction and contraction in cardiac muscle was first introduced by Ringer , but since his day many modifications have been made, including the addition of metabolites such as pyruvate and glutamate To make a blood substitute for clinical use as an 'expander' after hæmorrhage or in post-operative hypotensive states, dextrans of appropriate molecular size have been prepared and added to these solutions to make them osmotically equivalent to plasma But, so far, it has not been possible, except by employing suspended red blood corpuscles, to make these solutions adequate carriers of respiratory gases

The introduction of antibiotics and ample supplies of anticoagulants have encouraged and established the use of perfusion and similar techniques for clinical purposes The 'artificial kidney', which has proved successful in the management of certain types of kidney disorder, is a development of Abell's (1922) vividiffusion apparatus The principle is that an artery is cannulated and the blood, rendered incoagulable, is passed through a 20–30 m length of 'Cellophane' tubing which is formed into a spiral and rotated in a bath of modified Ringer's solution According to differences in concentration across the membrane, substances will be interchanged between the blood and the surrounding fluid By this means, substances which have accumulated because of renal dysfunction can be removed from the blood , the rate and the extent of the exchanges can be controlled by regulating the composition of the surrounding bath Ensuing chemical changes in the blood must be followed Treatment by the 'artificial kidney' is indicated when the pathological changes in the kidney are reversible and the patient's kidneys are likely to resume their functions

In the field of cardiac surgery more extensive and complicated operations have been made feasible during the past decade by the development of the 'extracorporeal circulation' This is a method, based on techniques well established in physiological laboratories, by which the systemic circulation of the body can be maintained by a mechanical pump and a blood oxygenator for a period during which the heart and the lungs of the patient can be by-passed. The heart and its neighbouring vessels can then be opened and congenital abnormalities or valvular lesions repaired or modified There are many problems in the design of pumps and oxygenators which, while giving, respectively, adequate flow of blood and sufficient exchange of respiratory gases, will not injure the blood Striking clinical progress has already been made and it seems likely that the improvements in the technique of perfusion will be applied to further studies of organ function and control and, probably, of survival *in vitro*

PERCEPTION, ATTENTION AND CONSCIOUSNESS

IN her presidential address to Section *J* (Psychology), Prof Magdalen D Vernon points out that we can never be aware at any one moment of the whole of our surroundings The degree to which we are aware of them varies greatly, from a precise perception of a narrow central field of view upon which attention is focused, to a vague awareness of all other parts We can vary the amount of attention and the accuracy of perception from moment to moment, and direct it to different parts of our surroundings , but the area of the field, and the number of events or objects in it, of which we can be aware at any one moment are limited Focal awareness of one part of the field may preclude the perception of surrounding parts It appears to be possible, however, to perceive events without being immediately aware of them and to store the information and attend to it later , but such information cannot be retained for long However, there is evidence to show that even when such information never reaches consciousness, it may yet have some effect on thoughts and behaviour

Various factors operate to produce a selection of what is perceived and attended to most closely We tend to perceive primarily what we expect is most probable to occur in the circumstances , and our previous experience of similar situations does much to determine the estimation of probability However, expectation is also affected by the reception of special instructions and information, and by training in what to look for People may also tend to perceive readily what they desire to perceive or are interested in perceiving , but in such circumstances they may imagine they see what is not actually there Again, they may be unusually slow to perceive what would be disagreeable to them But they quickly become aware of sudden and unexpected events which are significant and perhaps potentially dangerous, although they may be slower to perceive fully the exact nature of these events

It is difficult to perceive anything which is exposed only momentarily, or in very dim illumination, or in the margin of the field of vision Nevertheless, there is some evidence to show that material exhibited below the normal threshold of vision, of which the observer is not directly conscious, may in some circumstances affect his thoughts or behaviour, and in particular produce reactions of the autonomic nervous system Attention tends to wander after a time from events of no great interest which recur repeatedly and monotonously, and they may cease to be perceived A long period of exposure to completely homogeneous surroundings produces a decrease in awareness and the power of discrimination, accompanied in some cases by hallucinations and unpleasant emotional reactions

Recent physiological evidence as to the nature and functions of the reticular formation in the sub-cortical regions of the brain suggests that impulses from this formation may stimulate the cortex in such a way as to produce both a general arousal of consciousness , and also the direction of specific awareness to events of particular significance to the individual Cortical impulses in turn may facilitate these activities of the reticular formation, or may inhibit them, for example, in situations associated with the withdrawal of attention, such as those of repeated unvarying stimulation of no interest or importance to the individual Clearly these findings have considerable significance in relation to the psychology of perception and attention, though our understanding of their exact bearing must await further investigation

PLANTS ON LAND AND IN THE OCEANS

FOR his presidential address* to Section *K* (Botany), Dr W R G Atkins prepared an account of the many and varied problems on which he had worked and for which his initial training as a botanist had proved invaluable Starting with a brief account of his work on the suitability and preservation of the timber and fabrics used for the aeroplanes of the First World War, he passed on to an account of his work after the War for the Imperial Department of Agriculture in India It was in India that he started his studies on the *p*H of soils and plant juices, work which he later extended in Britain After his appointment to the staff of the Plymouth Laboratory of the Marine Biological Association, he was able to use *p*H measurements for assessing the total quantity of photosynthesis in water masses in the sea and to initiate complementary chemical hydrographical work at the International Hydrographic Station *E*1—work which has been continued by the staff of the Plymouth Laboratory ever since

Dr Atkins then gave an account of his extensive investigation into the penetration of light into the sea, a factor of great importance for the growth of the phytoplankton These studies were later extended to include measurements of light scattering and of the nature of the light fields to which plants in various environments are subject, both in air and under water In addition to this work, his interest in the plants of the phytoplankton continued Anomalies were often apparent when the crop of phytoplankton was estimated from measurements of the utilization of different nutrients That these anomalies were due to the occurrence on occasion of unsuspectedly large amounts of non-siliceous species was suggested by Dr Atkins—a hypothesis that his later observations and those of other workers have amply confirmed

Curious delays in the time of the spring outburst of the phytoplankton when determined by the sudden reduction in phosphate in the water mass were also sometimes observed These delays did not seem to be due to physical factors, since both the light and temperature were apparently suitable for rapid plant growth A study of the concentration of silicate and of the various species occurring in the water indicated a sudden influx of a fresh water mass into the area—a phenomenon not apparent from records of the temperature, salinity and phosphate, nor from measurements of the total plant population as measured by chlorophyll estimations Thus, after thirty years, at least one good reason for the lateness of the phytoplankton crop had become evident This, however, is not to say that at other times and places changes in the vertical circulation or other factors may not be important It does, however, indicate the value and necessity of the close integration of studies concerned with the concentration changes of all the known nutrients, the physical factors involved and both the total plant population and the occurrence of individual species

PATHOGENIC FACTORS IN THE ROOTING SPACE AND THE DEVELOPMENT OF EVEN-AGED PLANTATIONS

IN his presidential address to Section *K** (Forestry), W R Day says that the distribution of species of tree within the range grown for economic purposes is closely related to productive capacity as determined by available site types adequate freedom from acutely damaging infestations and freedom from infections are, plainly, related necessities Production is based on growth as a natural biological process and its economic value depends partly on rate of growth and partly on quality of production as determined by market value of produce or services rendered Ordinarily, the development of the main stem provides the principal interest in production, and this is governed by the interaction of crown and root as functioning correlatives Given adequate climatic adaptation of species of tree, then, within any suitable limited climatic range, the more important basic environmental variations which determine variations in production-rate are to be found in soil conditions as affecting root growth and functioning

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* Prepared from notes left by Dr Atkins and read posthumously by Dr C P Spencer, of the Marine Biology Station, University College of North Wales, Bangor

The general tendency in development in forests established as even-aged regenerations is from simplicity towards complexity in canopy structure, the rate of development of this tendency for any given species of tree and assuming relative evenness in climatic conditions is largely a function of the soil conditions which prevail locally The factors which determine the course of development in canopy structure are partly to be found in sylvicultural treatment, but basically in the developing demand by the forest canopy as crowns increase in size, especially during the first decades after regeneration, with reduction in number of stems per unit area and increase in height of tree, and according as this demand can be satisfied by supply of root growing-space as qualified by available water and nutrients Potential demand of a canopy of any given specific composition, according to size of tree and as influenced by stand density, may be considered as a genetic characteristic Since the degree to which this potential demand can be satisfied is determined largely by soil supply conditions it follows that, for any given age and type of even-aged regeneration, variations in canopy development which are natural to the site will occur according to the distribution of variations in the stage of stand development at which volume of canopy demand becomes marginal with site supply and especially with supply from the root growing-space Examples taken from even-aged Sitka and Norway spruce stands are given which illustrate variations in stand structure determined in this way Limitations in edaphic supply necessary for root development and action arise from a complex of physical, chemical and biotic factors the action of which is more or less interrelated Examples based mainly on the physical aspect of clay and sand soils, as observed in the field, are given to illustrate edaphically determined limitation in supply which, through the prevention of growth naturally attempted, acts as a basic cause of disease and in this way influences stand development and, through this, economic production

Examination of the problem of management of even-aged plantations suggests that if the effects of technical sylvicultural treatments are sufficiently to be appreciated, there must be some adequate understanding of the locally occurring inter-relationships between canopy development and site supply of the needs for this, for this, through basically controlling the type of growth possible. will largely determine the effectiveness of the technical treatments practised

WHAT ARE OUR SCHOOLS FOR ?

SIR JAMES J ROBERTSON, president of Section *L* (Education), opens his address by pointing out that it was only within a few weeks of each other that a Scottish judge and the Home Secretary spoke last winter about increased crime and irresponsibility They called for greater help from the schools, only to be rebuked by leading educational journals, which put the blame on bad influences outside Such criticisms focus widespread confusion about the schools' functions and society's ability to protect itself

Our educational philosophy is admirable, but our practice belies our professions, and, while within the task allotted to them our teachers merit respect and commendation, no part of our national education, except our enlightened infant departments, justifies complacency in face of the crisis of our time Admittedly, the ablest pupils in our grammar schools are equal to the demands made on them But do we allow time for their knowledge to be fully assimilated ? To what extent do we quicken sensibility in them, or nourish imagination, or awaken the sense of dependence on others ? Moreover, if we segregate the highly gifted in separate schools at eleven, do we not aggravate the risk of producing 'Lucky Jims' or an arrogant self-appointed élite ?

The average grammar school entrants, supposedly most fortunate, are educationally the worst used of all Despite advantages in staffing and provision, they are the victims of an unsuitable curriculum and an external examination too hard for the majority They suffer from excessive demands on their time, a low level of real attainment, an obsessional concern with examinations, and deplorable neglect of the non-cognitive sides of their natures The vision of the Norwood Committee and the Scottish Advisory Council quickly died amid post-war careerism and greed

Equally deplorable is the largely lost opportunity in the secondary modern schools, with the discrediting of interest and experiment and the ever-increasing participation in the chase after certificates, a participation which can, however, be defended if the General Certificate of Education really matters as much as we pretend, and we put into secondary moderns children capable of securing even scrappy certificates

The bright promise of 1943 for the primary schools also faded swiftly in the universal scramble for status A secondary education like that in Britain presupposes a primary, geared to '11 +', with tests and streaming all the way and those pressures that make short work of frills and experiments Add the excessive size of classes and general inadequacy of provision, and you ensure the dominance of class-teaching and the rigid time-table, with disastrous consequences both to secondary schooling and to any further education adequate to our condition

Further education which is neither vocational training nor purveyed entertainment is at once the most important of all, and in its meagre extent the most disappointing How can it be otherwise so long as statutory schooling creates distaste and does but scant justice to music, drama and the arts ?

Education in Britain accords as ill with recent thinking and discovery as with the sombre realities of our times, taking insufficient account of the rarity of high intelligence, the great range of innate ability and the powerful movements of thought towards an organic and unitary view of man as existent and person Our great need is to awaken to the costliness, both material and spiritual, of all true education reform must begin with a national change of heart

BALANCE IN BRITISH FARMING

DR H G SANDERS suggests in his presidential address to Section *M* (Agriculture) that the forty-seven years life-time of the Section has seen science applied to British agriculture at an ever-increasing rate, and there have also been violent economic changes Farming systems which have been built up in more leisurely times have achieved a balance which might be upset by these scientific and economic impacts There has clearly been an improvement in some aspects of the really basic factor—soil fertility The lime status of the soils of Britain has been raised markedly and is still improving, and the increasing use of chemical fertilizers has led to better plant nutrient content In regard to drainage the situation is less satisfactory There is still uncertainty and much argument over the importance of maintaining the organic matter content of the soil, the danger being that, if it is allowed to fall, soil structure will be lost New chemicals have proved powerful aids in keeping land clean, but there are obvious dangers in their indiscriminate use On many farms the ley has replaced the root crop as the pivot of the rotation, and advanced practitioners are showing how great the production from newly established grass can be Full summer utilization necessitates conserving surplus herbage at peak periods of growth, and silage fits better into advanced grazing control than hay Much is known about the extra cost involved in making high-quality hay and silage, but little about the increased animal production from first-class material and its possibilities in economizing expensive concentrated foods There is urgent need for more applied research into such problems

One aspect of balance in traditional farming systems has been the relation between the feeding-stuffs produced from the land and the head of livestock maintained A high degree of self-sufficiency is still a sensible economic aim, but its attainment depends on high-quality roughages and more precise knowledge of their potentialities, not only as maintenance ration but also for animal production.

A rough balance in the farming of Britain as a whole has grown up in a somewhat haphazard way Sales of store sheep in Scotland are well established, and similar ones for store cattle have recently started and are developing rapidly on the Welsh border The reverse movement of grain and straw from east to west is unorganized and depends on the initiative of individual merchants British farmers have had outstanding success in the development of pedigree livestock, but the future will probably see more use of crossbreds for commercial exploitation In poultry this is already widespread and in sheep also, though with them the benefits are often lost by continuing and indiscriminate crossing The development of a system of pedigree breeders and crossing breeders to provide livestock for the ordinary farmer would help in the simplification of farming which advancing knowledge is making ever more necessary The ultimate solution of this problem of keeping abreast with science should not be monoculture, but mixed farming with the more scientific processes in the hands of specialists

THE ST. LAWRENCE SEAWAY AND POWER PROJECTS : GEOGRAPHICAL BACKGROUND

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THE official opening of the St Lawrence Seaway on June 26 brought to completion five years of design and construction of both the Seaway and Power Projects on the St Lawrence River It also brought to fruition more than fifty years of almost incessant agitation in both the United States and Canada for the development of a deep navigable waterway into the heart of the North American continent Yet most significant of all, it will carry one stage further a process that has been under way for nearly four hundred years, since Jacques Cartier was halted in his journey up the St Lawrence by the Lachine Rapids This process has involved on one hand the gradual exploitation of physical features of the Great Lakes–St Lawrence drainage system advantageous to navigation, and on the other, the overcoming of natural obstacles to navigation Successive stages in this process have reflected the economic development of the continent as well as political changes The St Lawrence Valley is the natural outlet of the continent to the North Atlantic and western Europe , therefore, improvement of this waterway was to be expected However, nearly four centuries since European man first arrived on the scene the navigation facilities on the St Lawrence have only just been improved to the point where ocean-going vessels of more than 2,500 tons can be accommodated These navigation facilities are still not comparable with the other great canal systems of the world At present, the Panama, Amsterdam, Rhine, Kiel, Suez, Texas and Manchester Ship Canals all exceed in size the proportions of the St Lawrence Seaway facilities For an explanation of the long delay in the 'coming to age' of the navigation facilities throughout the Great Lakes–St Lawrence system, geographical, historical, economic and political factors must be considered

The St Lawrence River system in combination with the Gulf of St Lawrence and the Great Lakes provides a continuous waterway extending 2,347 miles into the heart of the North American continent from the Atlantic Ocean The length of this waterway, its location and orientation, are three of its outstanding geographical characteristics Mere length alone is not necessarily an economic attribute However, in this case the distance of the penetration into the continent, which is comparable with the great circle route distance between west European ports and the estuary of the St Lawrence, is of the very greatest economic significance because the Great Lakes–St Lawrence system provides an approximate east–west routeway into the heart of one of the richest agricultural and industrial regions on the face of the Earth, a region lying due west of the metropolis of Europe and the British Isles In relation to resource production and potential this routeway is ideally located Its hinterland or contributory region, comprising as it does the Canadian Shield, the greater part of the Interior Lowlands and parts of the central and northern Appalachian System, is extremely rich in agricultural, forestry, mineral and water-power resources It was natural that one of the world's major trade routes should develop between such a region and a heavily industrialized and densely populated Europe

The St Lawrence River provides the only completely natural water gap through the mountain and upland barrier formed by the Appalachians and the south-eastern upturned edge of the Canadian Shield , but for only brief periods in the past four centuries has it been the chief transportation route between the Atlantic and the interior of the continent The St Lawrence has faced competition from Hudson Bay, the Mississippi Valley, the Pacific Coast–Panama Canal route and especially the Lake Erie–Mohawk–Hudson route The economic and political history of the St Lawrence can largely be told in terms of its continued competition with the alternative routeways from the interior of the continent The low-level link between Lake Erie and the port of New York provided by the valleys of the Mohawk and the Hudson gained the ascendancy over the St Lawrence route with the completion of a barge canal between Buffalo and Albany in 1823 The ascendancy resulted partly from a major physical advantage of the more southerly route, and partly from the fact that it was an 'all-American' route between the Middle West and Europe

The major physical advantage of the Lake Erie–New York route is the year-round ice-free condition of the port of New York Inherent in the location of the St Lawrence, a location which in all other respects has proved advantageous, is one of its most serious limitations The winter climate of a region so located in the north-eastern quadrant of a continent within the northern hemisphere is long and extremely cold Below freezing temperatures for at least four months result in the St Lawrence being turned into an iceway rather than a waterway From the year 1887 until the present day the average date on which the ship channel between Quebec and Montreal has been open for navigation has been April 17 , the earliest date throughout that period was March 19 and the latest date May 1 The average date of the last departure from Montreal was December 4, the earliest was November 21 and the latest December 19 Amelioration of conditions during the past decade and more recently assistance from icebreakers have resulted in the lengthening of the navigation season by about two weeks With the completion of the Seaway it has been suggested that the navigation season might well be even further lengthened by an increase in the number and the efficiency of icebreakers, the use of aerial ice surveys and the improvement of aids to navigation

An eight-month navigation season on the St Lawrence and the Great Lakes compared to year-round navigation on the Atlantic coast south of the Gulf of St Lawrence has probably militated against the development of the full potential of the St Lawrence and the Great Lakes more than any other factor, though if deep navigation had been more readily available this limitation would perhaps not have been considered quite so disadvantageous

The other major physical limitation of the Great Lakes–St Lawrence waterway has been, of course, the series of falls, rapids and shallow connecting channels, which unfortunately abound within the system, especially between Montreal and Lake Huron The long delay in successfully circumventing these obstacles has not been due to engineering difficulties but rather to the sheer expense involved In the upper St Lawrence, that is between Montreal and Lake Ontario, all the pre-Seaway canalization was undertaken by Canada, at an expense which was very considerable for a relatively small and youthful country Only in recent years when it became feasible to merge schemes for the provision of navigation facilities and the development of hydroelectric power did the expense appear not too burdensome, for both Canada and the United States It is fortunate that the most serious liabilities of the whole Great Lakes–St Lawrence system are, at one and the same time, very great assets The upper St Lawrence, which has over the years proved the most serious obstacle to the improvement of navigation, to-day provides almost 4,000,000 horse-power of electricity

The natural deep navigation throughout much of the Great Lakes and on the lower St Lawrence and the falls and rapids, seen either as obstacles to navigation or as water-power sites, owe their existence to a varied geological and physiographical history The entire drainage system of the Great Lakes and the St Lawrence covers an area approximately 678,000 square miles in extent, within three of the major geological and physiographical regions of the continent the Interior Lowlands, the Canadian Shield and the Appalachians The Great Lakes and the valley of the St Lawrence lie chiefly within the north-eastern section of the Interior Lowlands Here a great series of Palæozoic sedimentary rocks, primarily limestones, dolomites, shales and sandstones, take a basin-like form, overlapping on to the rocks of the Shield and the Appalachians to the north and the east Differential erosion on these Palæozoic rocks has produced a series of cuestas best typified by the famous Niagara Escarpment, and lowlands, which are to-day partly occupied by four of the Great Lakes and sections of the St Lawrence Valley In general, dolomites and limestones tend to form the higher parts of the region and are the 'fall-makers', while the shales have been removed extensively to form the lowlands and particularly the four lower lake basins Lake Superior lies entirely within the Precambrian rocks of the Canadian Shield The Great Lakes probably owe their origin to a combination of events—structural depression, fluvial erosion, glacial deepening and morainic damming These events gave rise to the great size and depth of the Great Lakes The deepest point in Lake Superior is 1,302 ft , that is, 700 ft below sea-level, while Lake Michigan has a maximum depth of 923 ft , Lake Huron 750 ft , Lake Ontario 774 ft , Lake Erie is relatively shallow, with an average depth of only 58 ft The water surface of the Great Lakes covers an area of 95,000 square miles, an area almost as great as that of the British Isles

The surface of Lake Superior averages 602 ft above sea-level The drop to sea-level is concentrated in two sections of the drainage system between Lakes Erie and Ontario and in the upper St Lawrence between the outlet of Lake Ontario and Montreal There is a total drop of 326 ft from Lake Erie to Lake Ontario, with a vertical drop of 168 ft at Niagara Falls, where the outflow of Lake Erie drains across the resistant Lockport dolomite of the Niagara Escarpment Between the outlet of Lake Ontario and Montreal the St Lawrence drops a total of 246 ft in a distance of 183 miles, and in doing so flows across alternating resistant igneous and weaker sedimentary rocks, which has given rise in turn to a series of alternating rapids and lake basins Immediately on leaving Lake Ontario the St Lawrence flows across a southerly extension of the Canadian Shield, the Frontenac Axis This section is known as the Thousand Islands , it is wide, deep and free of rapids Below it a series of four rapids, collectively known as the International Rapids, because here the Canada–United States border runs along the St Lawrence, provide a drop of 92 ft in a distance of 44 miles These rapids, including the famous Long Sault, have to-day disappeared under the power pool of the St Lawrence Dam Here the engineers won a brilliant victory over the St Lawrence by raising the waters of the river 81 ft behind a dam built below these falls They have developed tremendous water-power and at the same time provided excellent deep navigation which replaces a series of four 14-ft deep canals of the old St Lawrence canal system

Downstream from the International Rapids section Lake St Francis drains via another series of four rapids with a total drop of 82 ft Again this major obstacle has been circumvented by a combined power pool and deep waterway known as the Beauharnois Canal Here again there is a potential 2,000,000 horse-power of electricity, three-quarters of which has already been developed The final major drop of the St Lawrence occurs where Lake St Louis drains over the Lachine Rapids The drop of 50 ft has not yet been harnessed for the development of electric power, and the Lachine Rapids have remained solely as an obstacle to navigation They have additional geographical significance in that the city of Montreal has developed largely as a result of the Lachine Rapids bringing natural deep navigation to an end at this point

The value of the many considerable drops in elevation within the Great Lakes–St Lawrence system as water-power sites is considerably enhanced by two additional physical attributes of the region The Great Lakes in particular, but also the myriads of large and small glacial lakes within the Canadian Shield, act as vast reservoirs with a tremendous storage capacity which results in the outflow not only being considerable but also in being regulated to a remarkable degree The maximum average flow is about 310,000 cu ft per sec and the minimum 144,000 cu ft per sec The variation of about 2 to 1 is in striking contrast to the flow of the Columbia River, with a ratio of 35 to 1, and the Mississippi River, with a ratio of 25 to 1 The average flow in cu ft per sec obviously increases downstream, being 71,000 between Lakes Superior and Huron, 194,000 on the Niagara River, 237,000 in the International Rapids section, and it reaches a maximum volume of 262,000 cu ft per sec where the Ottawa River joins the St Lawrence The relatively uniform annual precipitation within the drainage basin also contributes to the uniform flow and the tremendous volume of water in the system Precipitation varies from 25 to 43 in , with a mean of 33 in

The completion of the combined St Lawrence Seaway and Power Projects brings to a satisfactory stage the development of navigation facilities on the Great Lakes and the St Lawrence and brings closer the complete utilization of the tremendous water-power available Man has long awaited the day when the full economic potential of this vast system would be realized This stage may not yet have been reached, but economic and technological development will probably no longer hinder absorption of any remaining potential into the navigation and power systems of the Great Lakes and the St Lawrence

(Continued from page 34)

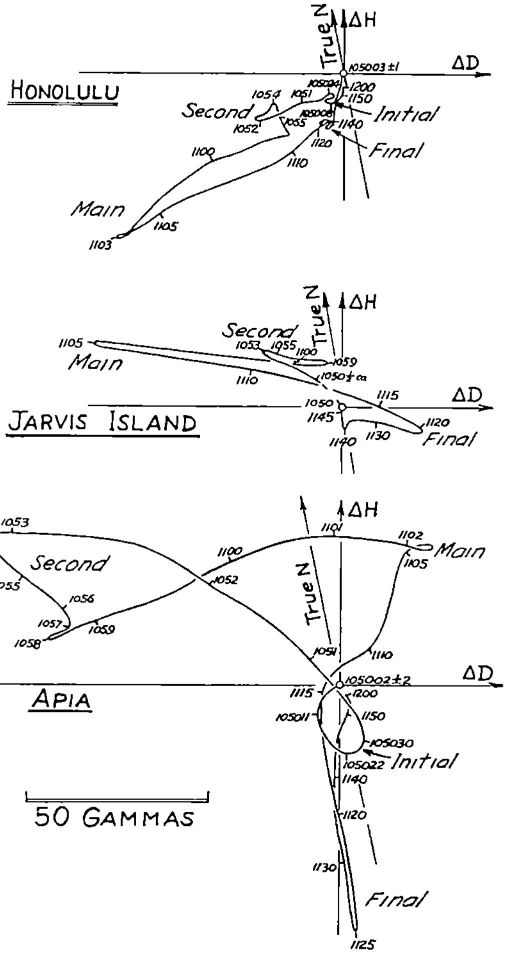

Fig 2*a* Vector diagrams showing the horizontal plane magnetic effects of the explosion of August 1 Times are G M T

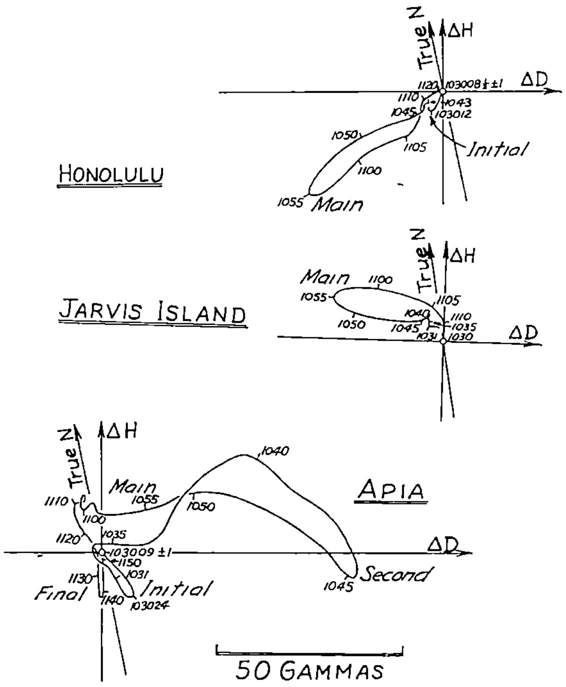

Fig 2*b* Vector diagrams showing the horizontal plane magnetic effects of the explosion of August 12 Times are G M T

local *E*- or *F*-region winds in the area of increased ionization produced by these particles, particularly near the conjugate point

Main phase Gas motion due to the explosion which, by the time of maximum of this phase, extends to the region of the meridians through Honolulu and Jarvis Islands G A M King and C H Cummack (personal communication) independently propose a shock front spreading from Johnston Island with radially uniform horizontal speed They associate the arrival of this at each station with the time of maximum of the main phase there, except at Apia, where they associate it with the time of maximum of the final phase

Adopting the idea of a circular horizontal boundary centred on Johnston Island, applied to an expanding conducting cloud, we suggest a broad qualitative interpretation of the magnetic vectors as follows

Fig 3*A* shows the type of distortion produced in the horizontal magnetic field, assuming that the lines of force are to some extent frozen in the gas

Fig 3*B* shows a current system which might be produced by the e m f induced in the northern section of the cloud moving against the Earth's vertical magnetic field, with return current moving preferentially along the meridian and linking up in the region of high ionization near the conjugate point

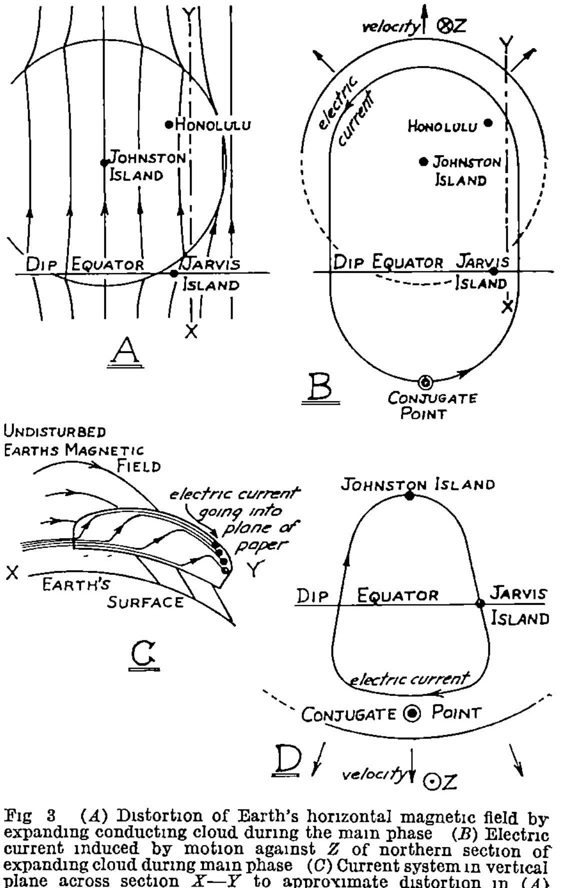

Fig 3 (*A*) Distortion of Earth's horizontal magnetic field by expanding conducting cloud during the main phase (*B*) Electric current induced by motion against *Z* of northern section of expanding cloud during main phase (*C*) Current system in vertical plane across section *X*—*Y* to approximate distortion in (*A*) combined with the current system of (*B*) (*D*) Electric current induced by motion against *Z* of southern section of expanding cloud during final phase

Fig 3*C* shows a vertical section across *X–Y* of Figs 3*A* and *B* In this is pictured a current system which is imagined to combine that of 3*B* with currents to approximate the distortion shown in 3*A*

Note that the return current across the equator contributes to the required distortion, and we suggest that this as well as anisotropic conductivity control the direction of flow.

Final phase A later development of the motion producing the main phase, corresponding to the passage of the shock front over Apia as postulated by King and Cummack In Fig 3*D* we suggest an interpretation of the magnetic vectors on this idea This current system would depend on the abnormal ionization still situated in the whole region between Johnston Island and the conjugate point

The development of all phases after the first explosion is faster, and affects a wider region, consistent with the belief that the first was the highest

We hope to publish a full account of this work in the *N Z Journal of Geology and Geophysics*

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[1] Cullington, A L, *Nature*, 182, 1365 (1958)
[2] Kellog, P J, Ney, E P, and Winckler, J R, *Nature*, 183, 358 (1959)
[3] Akasofu, S, Rep Ionospheric Res in Japan, 10, 4, 231 (1956)
[4] Fowler, P H, and Waddington, C J, *Nature*, 182, 1728 (1958)

Some Geomagnetic Phenomena associated with Nuclear Explosions

The three International Geophysical Year stations operated in the central Pacific by the Scripps Institution of Oceanography have consistently recorded magnetic disturbances following, and apparently caused by, the various nuclear tests conducted by the British in the vicinity of Christmas Island This fact is particularly interesting because, unlike the American bomb which was exploded in the ionosphere over Johnston Island on August 1, 1958, producing auroral and magnetic effects over a large area of the Pacific[1], the British tests are believed to have occurred at relatively low altitudes in the lower atmosphere

Fig 1 shows magnetograms for the explosion of April 28, 1958, and Fig 2 the positions of the observing stations relative to the shot point, which was stated to have been within ten miles of 1° 40′ N, 157° 15′ W The altitude has not been disclosed, but official reports indicate that the device was dropped by a *Valiant* jet bomber, and it may be supposed that the height of detonation was substantially less than the ceiling of about 60,000 ft for that class of aircraft

The pronounced anomalies in *Z* and *D*, which reach a maximum at Jarvis and Fanning between 12 and 15 min after the event and at Palmyra about 10 min later, are similar in character to those which followed other tests, and we have no doubt that they are directly related to the nuclear explosion We have examined magnetograms from the nearest magnetic observatories outside the immediate area, that is, Apia, Guam and Honolulu, but have not found any magnetic effects that we can positively identify with this or with any other of the British tests This is surprising, because Apia and Honolulu are only about three times as far as Palmyra from Christmas Island

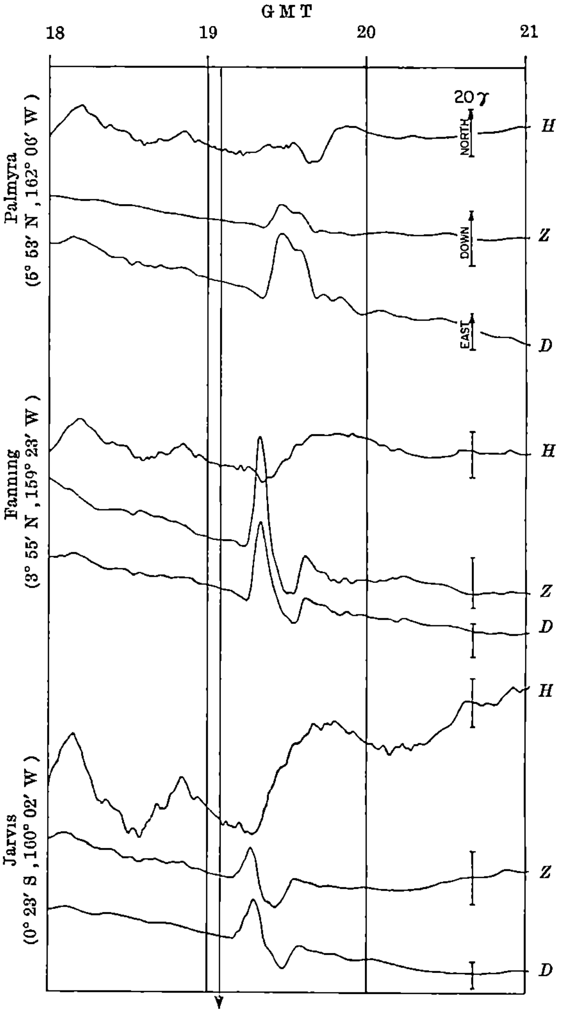


Fig 1 Magnetograms for the Christmas Island nuclear explosion of April 28, 1958

The disturbances recorded at our three stations have several features in common They begin quite suddenly after a delay of several minutes (rather longer at Palmyra than at the other two stations), they move in the same relative phase and they persist for about half an hour, but perhaps the most striking feature of the magnetograms is the absence of any observable disturbance in *H* corresponding to the major disturbance in *Z* and *D* (though an unusual, and probably related, type of local disturbance in *H* at Palmyra commenced about 26 min after the event and lasted for about 20 min) The absence of an *H* component would be explained if the phenomenon involved horizontal currents parallel to the magnetic meridian, and in this connexion it may be noted that the Earth's magnetic field is very nearly horizontal throughout the area More generally, possible mechanisms for producing such disturbances include (*a*) the motion of charged particles, in certain circumstances controlled by the Earth's magnetic field, (*b*)

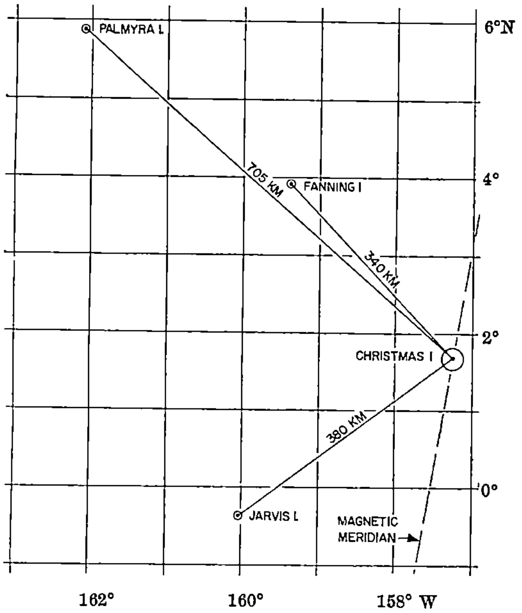


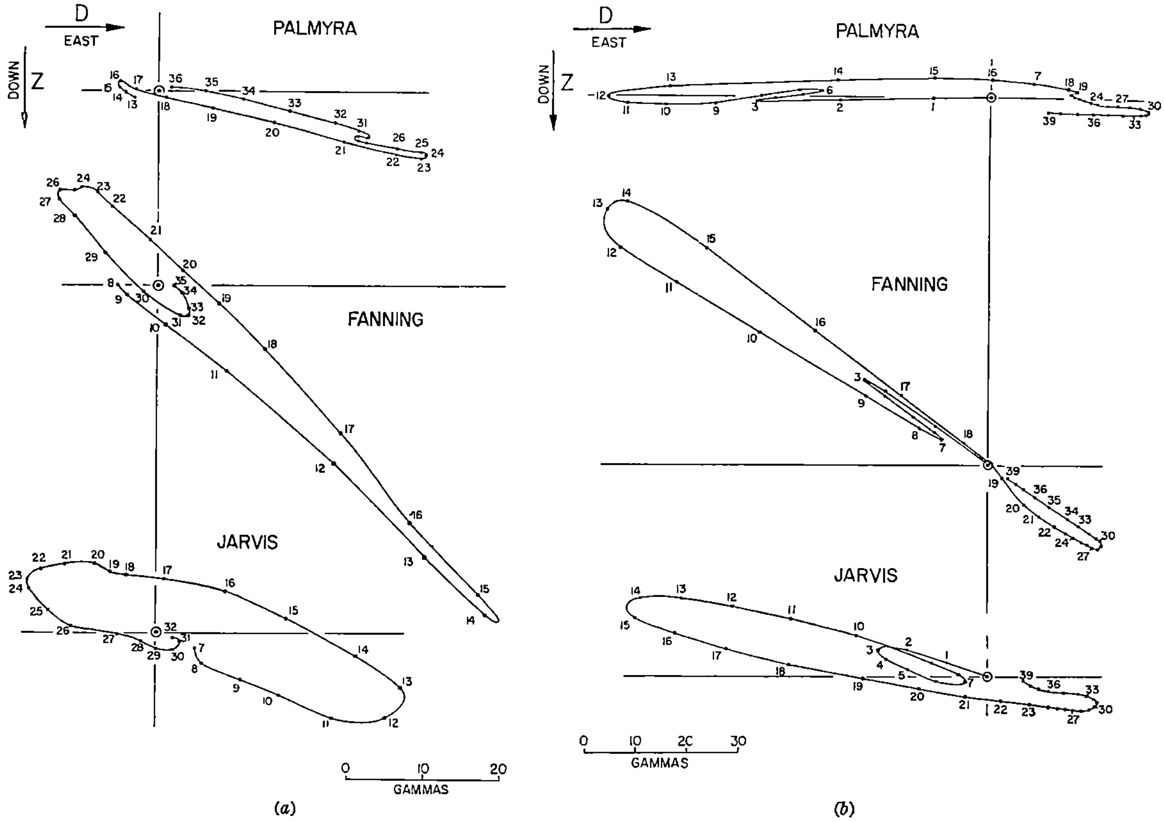
Fig 2 Positions of the Scripps International Geophysical Year stations relative to the shot point near Christmas Island

the modification of existing ionospheric currents through displacement of the conducting medium or changes in conductivity, (c) the mechanical disturbance of a magnetic field frozen into a mechanically disturbed conducting medium To these must be added the secondary effect of induction within the Earth

In order to bring out more clearly the vector characteristics of the disturbances, diagrams have been constructed showing the time variation of their projections in various planes, measured as the departure of the observed field from an assumed smooth background (represented by the origin of the vector diagram). Fig 3*a* shows diagrams for the vertical plane perpendicular to the magnetic meridian The explanation of the large time delay at Palmyra is now seen to be that, although the vectors at all three stations reach peak values in one direction between 12 and 16 min and in the opposite direction between 23 and 27 min, the directions and amplitudes of the two peaks at Palmyra are reversed

Fig 3*b* shows the corresponding diagrams for the Johnston Island explosion of August 1, 1958 Having regard to the altogether different geographical positions and altitudes of the two events, the similarity of the two sets of diagrams is remarkable However, unlike the Christmas Island explosion, the Johnston Island event produced changes in H comparable in magnitude with those in D and Z Fig 4 shows vector diagrams of the disturbance in the horizontal plane, plotted to show the relative directions of the magnetic vector, Johnston Island and the conjugate point (taking Elliot and Quenby's position[2]) at each station This event produced effects not observed in connexion with the Christmas Island tests, for example, an instantaneous change in H of about 10 gammas

It is clear from the complicated nature of the Johnston Island disturbance, and from the extent to which it resembled the disturbance produced by the dissimilar Christmas Island event, that no simple



(*a*) (*b*)

Fig 3 Vector diagrams of the disturbance in the vertical plane perpendicular to the magnetic meridian for (*a*) the Christmas Island explosion of April 28, 1958, (*b*) the Johnston Island explosion of August 1, 1958 The small figures indicate the time in minutes after the event

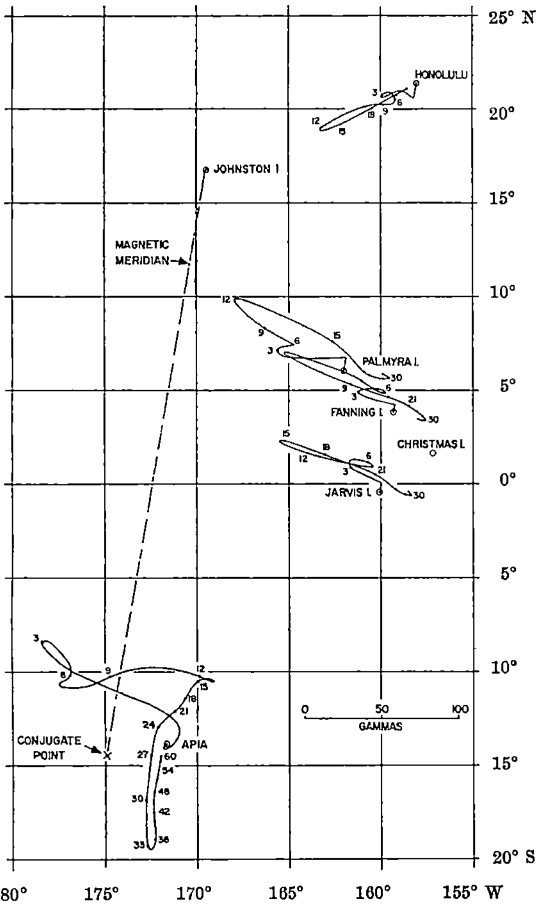


Fig 4 Vector diagrams of the disturbance in the horizontal plane for the Johnston Island explosion of August 1, 1958 The small figures indicate the time in minutes after the event

explanation of the magnetic phenomena is to be expected, it is probable that several distinctly separate mechanisms are involved

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[1] Cullington, A L, *Nature*, **182**, 1365 (1958)

[2] Elliot, H, and Quenby, J J, *Nature*, **183**, 810 (1959)

CHEMISTRY

Carrier Gas and Sensitivity in Gas Chromatography

A recent article[1] takes issue with the "popular belief that the use of hydrogen or helium as the carrier gas in gas chromatography gives the highest sensitivity with a thermal conductivity detector, because the difference in thermal conductivity between organic vapours and hydrogen or helium is greater than for any other carrier gas" The article goes on to show that, for methane and ethane at least, the sensitivities are considerably higher with carrier gases that have a lower thermal conductivity

The communication by Dr Ray, however, treats the special case where the bridge current of the detector is held constant In practice, not the bridge current, but the filament temperature is held constant Under these conditions, helium is nearly ten times as sensitive as argon

A standard C_4 hydrocarbon mixture was analysed on the same gas chromatographic column under the same condition with both helium and argon as carrier gases, while holding the bridge current constant at 150 m amp Values of the sensitivity parameter[2] (*S*-values) were calculated for the entire mixture; the *S*-value for argon was 252, for helium 300 *Ad hoc* experiments show that the filament temperature will be the same with helium as a carrier gas, operating with a bridge current of 350 m amp, as with nitrogen or carbon dioxide as carrier gas with a bridge current of 150 m amp; argon is in the same range as nitrogen or carbon dioxide The *S*-value for C_4 hydrocarbons in helium, with a bridge current of 350 m amp, is approximately 3,000 In argon, a bridge current of this magnitude would cause the filament to burn out The *S*-values obtained at the same filament temperature closely check the differences that would be expected for argon and helium based on the differences of their thermal conductivities and the thermal conductivities of hydrocarbon vapours helium is 3,480, argon 398, and *n*-butane 322

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[1] Ray, N H, *Nature*, **182**, 1663 (1958)

[2] Dimbat, M, Porter, P E, and Stross, F H, *Anal Chem*, **28**, 290 (1956)

While it is true that a higher sensitivity can be obtained by using a higher bridge current, it is not usually possible to do this with commercial gas chromatography instruments, because manufacturers wisely limit the supply voltage to a level at which the katharometer filaments do not fuse in air or nitrogen Even with home-made instruments the bridge supply voltage may be a limiting factor, since to maintain the same filament temperature in helium as in argon the voltage must be increased nearly three times

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Measurement of Intergranular Diffusion in a Silicate System: Iron in Forsterite

Many geochemists and petrologists[1] concerned with the role of solid state diffusion in material transfer in silicate systems have noted the possibility that grain boundaries and dislocations might act as avenues for relatively rapid movement of the diffusing ions Studies on metal systems are usually cited as evidence for this phenomenon We wish to report some preliminary measurements on a silicate system where grain boundary diffusion seems to predominate in diffusive transfer

The system used for the study was polycrystalline forsterite (magnesium orthosilicate) with ferrous ion as the diffusing material Pellets were prepared from stoichiometric mixtures of the pure oxides by compression at 15,000 lb./sq. in. and sintering at approximately 1,600° C. The samples were broken up and the operations were repeated four times to assure homogeneity. Radioactive iron-55 in a ferric chloride carrier was used as tracer, being applied as a spot in the centre of the forsterite disk. This was baked briefly at 1,000° C. to form ferric oxide, and then reduced at 900° C. in a controlled atmosphere of carbon dioxide and carbon monoxide adjusted to produce fayalite[2] (ferrous orthosilicate). After microscopic examination to detect imperfections and non-adherence, the sample was counted with an end-window Geiger counter under conditions such that the counting geometry could be reproduced exactly. The surface-decrease technique was used. The application of this method to the diffusion of iron-55 in oxides has been described in detail by Himmel, Mehl and Birchenall[3] and by Carter and Richardson[4], and similar methods were applied here. The diffusion annealing was carried out in the range 1,000°–1,200° C. in the controlled atmosphere furnace. Exploratory sections were taken in a few samples after diffusion by careful removal of active layers by grinding in a holder, and residual activity and thickness were measured after the removal of each layer. A few samples were ground at an angle, and autoradiographs were taken with Eastman 'No-screen' X-ray film.

Results for the diffusion coefficient as a function of temperature are plotted in Fig. 1. The straight line calculated according to the least-squares method corresponds to the equation

$$D = 4{\cdot}17 \times 10^{-6} \exp(-38{\cdot}8\ \text{kcal}/RT)\ \text{cm}^2\ \text{sec}^{-1}$$

The statistical limits for 95 per cent confidence for the activation energy are ± 3·6 kcal.

The results for sectioning are given in Fig. 2, for one typical example, and are plotted as log activity against both penetration distance and the square of this distance. According to Fisher[5], theory would predict a straight line in the former case for grain boundary diffusion, and a straight line in the latter case for lattice diffusion. It will be noted that grain-boundary movement is indicated. In all cases, autoradiography confirmed this conclusion. Penetration was found to be non-uniform and concentrated on lines and spots which were rather poorly defined, presumably because of the relative long range of the X-radiation from iron-55.

Despite their importance in geological, ceramic and metallurgical systems, few determinations of diffusion in solid silicate systems have been made. Most notable have been the measurements of Lindner[6]. His work indicates energies of activation for such systems of 47 kcal or greater. The value of 38 kcal found for the present system may be indicative of the greater ease of material transfer through grain boundaries. The picture of such interfaces as regions of ionic misfit with consequent concentration of lattice vacancies and dislocations makes the easier motion of solute ions through such sites readily understandable.

In most solid systems boundary diffusion is considered to play but a minor part in material transfer in comparison with lattice diffusion at temperatures above the Tammann temperature (approximately 0·5 T_m, where T_m is the melting point in degrees K.) because of the small area of the boundaries compared with the aggregate crystal area. The temperatures of the measurements of this study are in this range. However, in orthosilicates we have a close-packed array of ions which may be considered to offer a singularly unfavourable condition for lattice diffusion and prove an exception to the above rule. In such a system, boundary diffusion might be expected to be greater than lattice diffusion, and measurements do seem to give a relatively unambiguous indication that such boundary diffusion can play a part in transfer in a silicate system.

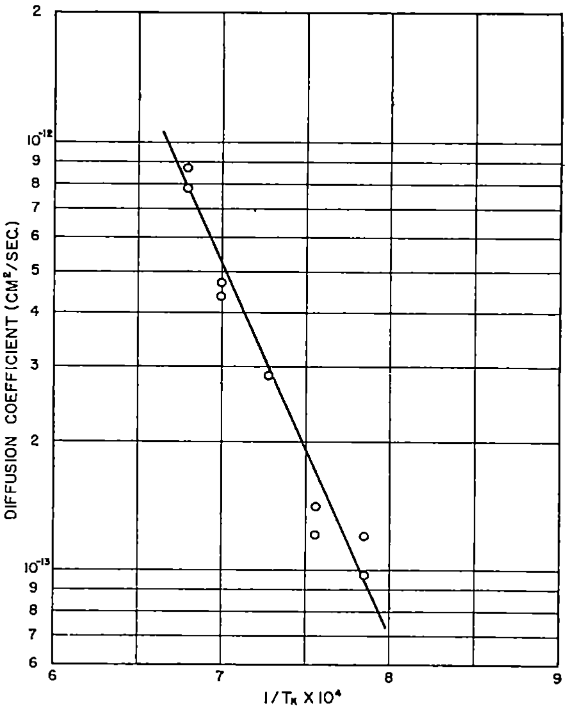

Fig. 1. Diffusion coefficient as a function of temperature

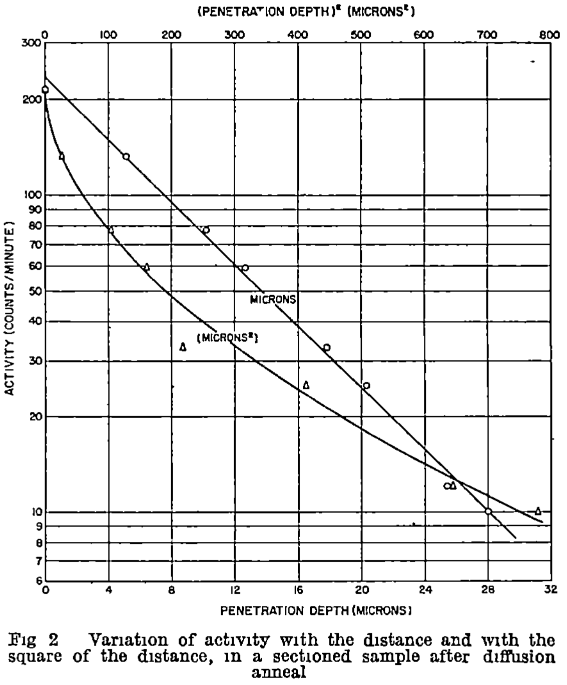

Fig. 2. Variation of activity with the distance and with the square of the distance, in a sectioned sample after diffusion anneal

It is of interest to calculate the distance of appreciable material transfer that would be possible through this intergranular pathway in geological periods of time—say, 10^6 years. By using the mean displacement equation, $X = (Dt)^2$, giving the relationship between the diffusion coefficient D, the time t, and the distance of transfer of the average concentration of diffusing material X, we can obtain an approximation of this last. In the range of 1,000°–1,200° C one finds that a displacement of only 5–17 cm is to be anticipated.

In considerations of petrographic metasomatic processes, particularly those involved in 'the great granite controversy', much argument has centred on the possible mechanisms of transfer of large quantities of matter, sometimes through great distances[7]. One group has sought to account for such transfer by solid state diffusion, and particularly by the intergranular pathway for such diffusion. Within the limitations of the conditions and the system studied, the above results would tend to support those who discount the role of diffusion in long-distance mass transfer, even through the supposedly easy route of the grain boundary.

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[1] Ramberg, Hans, "The Origin of Metamorphic and Metasomatic Rocks" (University of Chicago Press, 1952)
[2] Darken, L S, *J Amer Chem. Soc*, **70**, 2046 (1948).
[3] Himmel, L, Mehl, R P, and Birchenall, C E, *Trans Amer Inst Mech Eng*, **197**, 827 (1953)
[4] Carter, R E, and Richardson, F D, *Trans Amer Inst Mech Eng*, **200**, 1244 (1954)
[5] Fisher, J C, *J App Phys*, **22**, 74 (1951).
[6] Lindner, R, *J Chem Phys*, **23**, 410 (1955).
[7] Bowen, N L, Memoir 27 (Geological Society of America, 1948)

Influence of Gold in a Mercury Electrode on Certain Electrode Processes

It is usual to study electrode processes using hanging-mercury microelectrodes. Some authors prepare these electrodes by hanging a small mercury drop on a gold wire or a gold-plated platinum wire[1,2], deliberately neglecting the presence of the gold for its electropositive potential. Such an electrode is however an amalgam electrode, and, as we have shown[3], gold can influence the electrode processes of those metals which combine with it to form intermediate compounds.

The actual concentration of gold in different parts of the electrode is variable and dependent upon time, partly due to continuous diffusion of the gold. However, adopting certain approximations, it is possible to evaluate it. For a mercury drop with a radius of 0·05 cm on a gold wire with a surface area of 0·1 mm^2 the concentrations of gold in the mercury 20, 60, 200 sec after the drop was first suspended on the wire are, respectively, 0·001, 0·05 and 0·01 per cent. To ascertain whether those concentrations are sufficient to form intermetallic compounds on the surface of the electrode we have prepared 0·001, 0·01 and 0·1 per cent gold amalgams for use with the

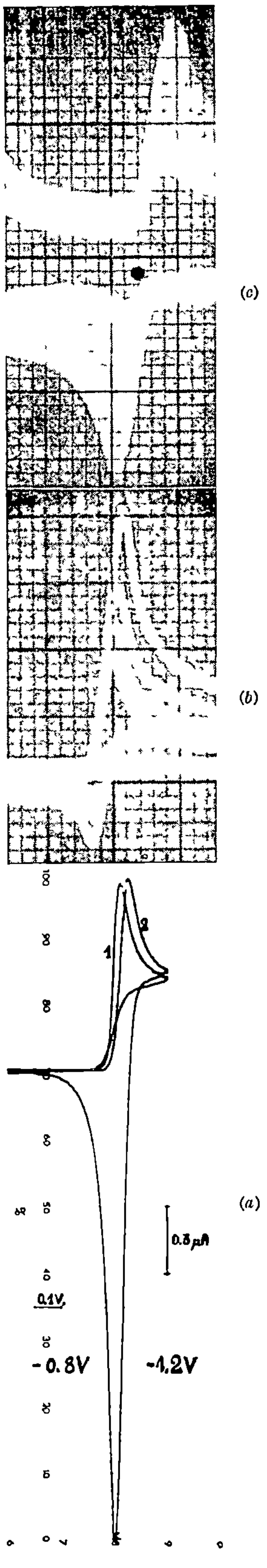

Fig 1

electrodes previously described[4] With these electrodes, $5 \times 10^{-4} N$ solutions of lead, thallium, cadmium and zinc ions were investigated, by means of cyclic polarization of the electrode, using different rates of voltage sweep and recording the corresponding voltammetric and oscillographic curves

It was confirmed that the presence of gold in the electrode greatly influences the electrode processes of zinc Fig 1*a* shows the cyclic voltammetric curves for zinc on the 0 1 per cent gold amalgam electrode (curve 1) and on a mercury electrode (curve 2) They differ significantly in both cathodizing and in anodizing

On gold amalgam the cathodic process is shifted about 20 mV towards more positive potentials compared with a pure mercury electrode The differences in the anodic processes are even more pronounced Zinc is not oxidized at the reversible potential (about -1 0 V), which is caused by the formation in mercury of a compound, AuZn, that can be oxidized at more positive potentials A similar effect can be observed even with less concentrated amalgams Fig 1*c* shows the oscillopolarographic curves for zinc at a frequency of 4 c /s when the exposure was 30 sec and the concentration of gold in the amalgam is 0 01 per cent The more pronounced effect is seen in Fig 1*b*, where the voltage sweep was 0 3 V /sec It is evident that both the reduction current for zinc ions, and the oxidation current of zinc from the amalgam, decrease with time when the compound AuZn is formed This does not occur with the pure mercury electrode The influence of gold can be neglected only when its concentration in the amalgam is less than 0 001 per cent

Similar effects were observed for cadmium, although the intermetallic compound AuCd is not so stable as AuZn Its formation can be observed when the concentration of gold exceeds 0 01 per cent No influence of gold on the electrode processes of lead and thallium was found

Those experiments show clearly that the use of gold or gold-plated wires for suspending the mercury drop can give erratic results if the formation of intermetallic compounds is neglected

On the other hand, our technique for preparing hanging-mercury drop electrodes does not suffer from this difficulty

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[1] Gerischer, H , *Z phys Chem* , **202**, 302 (1953)
[2] Mamontov, G , Papoff, P , and Delahay, P , *J Amer Chem Soc* , **79**, 4034 (1957)
[3] Kemula, W , Galus, Z , and Kublik, Z , *Nature*, **182**, 1228 (1958) , *Bull Acad Polon Sci* , Cl 3, **6**, 661 (1958)
[4] Kemula, W , and Kublik, Z , *Anal Chim Acta*, **18**, 104 (1958)

Carbonate Minerals in Hydrated Portland Cement

ALTHOUGH the physical effects of the carbonation of hydrated cements and mortars have been studied[1-3], the way in which the carbon dioxide is held has not yet been clearly established Most workers have assumed that it exists in the form of calcite , but in work at this Division[3,4] and elsewhere[5] the quantity of calcite detected by X-ray diffraction and differential thermal methods is always much less than the amount of carbon dioxide recoverable from the samples We have investigated this problem in some detail using samples of mortar and carbonated calcium silicate hydrate

From a study of the X-ray diffraction patterns of the materials before and after carbonation, using a Guinier-type focusing camera of high dispersion, we have concluded that the carbon dioxide is chemically bound as calcium carbonate largely in the form of poorly crystallized vaterite, aragonite and calcite These minerals have three-dimensional lattices , this does not support the suggestion of Gaze and Robertson[5], based on indirect evidence, that the carbon dioxide in carbonated tobermorite could be present as two-dimensional calcite Our results also show that well-crystallized calcite is present in small quantities, but that its amount is not greatly increased by carbonation In the past, X-ray analyses have determined the amount of this well-crystallized calcite, rather than the amount of the less easily detected poorly crystalline forms now proved to be present, and so have failed to account for all the carbon dioxide found in carbonated mortars

Other workers[1-3] have shown, and we confirm, that the calcium carbonate minerals have formed both from the decomposition of hydrated cement minerals and from calcium hydroxide produced during the hydration of $3CaO\ SiO_2$ (alite) to xCaO SiO_2 $y$$H_2O$ in the setting of the cement As a result they are intimately associated with a siliceous residue with which they readily react on heating In differential thermal analysis the decomposition of the poorly crystallized calcite produces only a slight endothermic effect (at about 700° C) and its reaction with the siliceous residue to form larnite (β-2CaO SiO_2) is not exothermic Therefore this method, too, gives little or no indication of carbon dioxide minerals other than well-crystallized calcite (strong endothermic effect at about 850° C) in carbonated mortars

Since carbonation of mortars requires the presence of moisture[1-3], we suggest that the process takes place through the action of carbonic acid on cement minerals yielding poorly crystallized vaterite, aragonite and calcite in the following manner Cement minerals → siliceous residue + calcium hydroxide → vaterite + aragonite + poorly crystallized calcite → well-crystallized calcite

A more detailed account of the investigation will be published elsewhere

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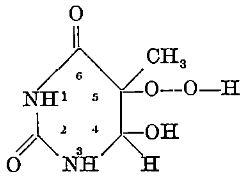
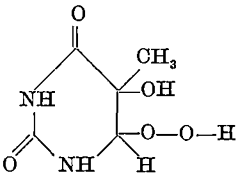
[1] Leber, I , and Blakey, F A , *J Amer Concr Inst* , **28**, 295 (1956) (*Proc* 53)
[2] Verbeck, G J , A S T M Spec Tech Pub No 205, 17 (1958)
[3] Kroone, B , and Blakey, F A (unpublished results)
[4] Cole, W F (unpublished results)
[5] Gaze, R , and Robertson, R H S , *Mag Concr Res* , **8**, 7 (1956)

IRRADIATION CHEMISTRY

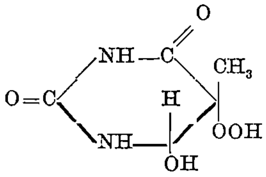
Structure of Thymine Hydroperoxide produced by X-Irradiation

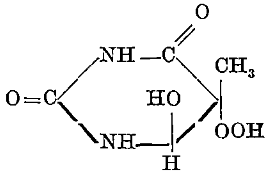
WEISS *et al.*[1] have shown that X-irradiation of aerated aqueous solutions of nucleic acids, pyrimidine nucleotides or pyrimidine bases gives rise to hydroperoxides. In the case of thymine, they proposed the following possible structures:

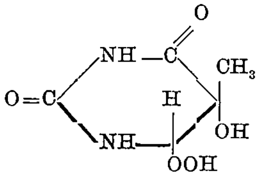

(I)

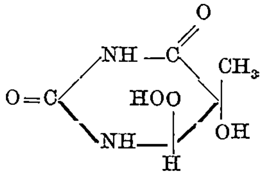

(II)

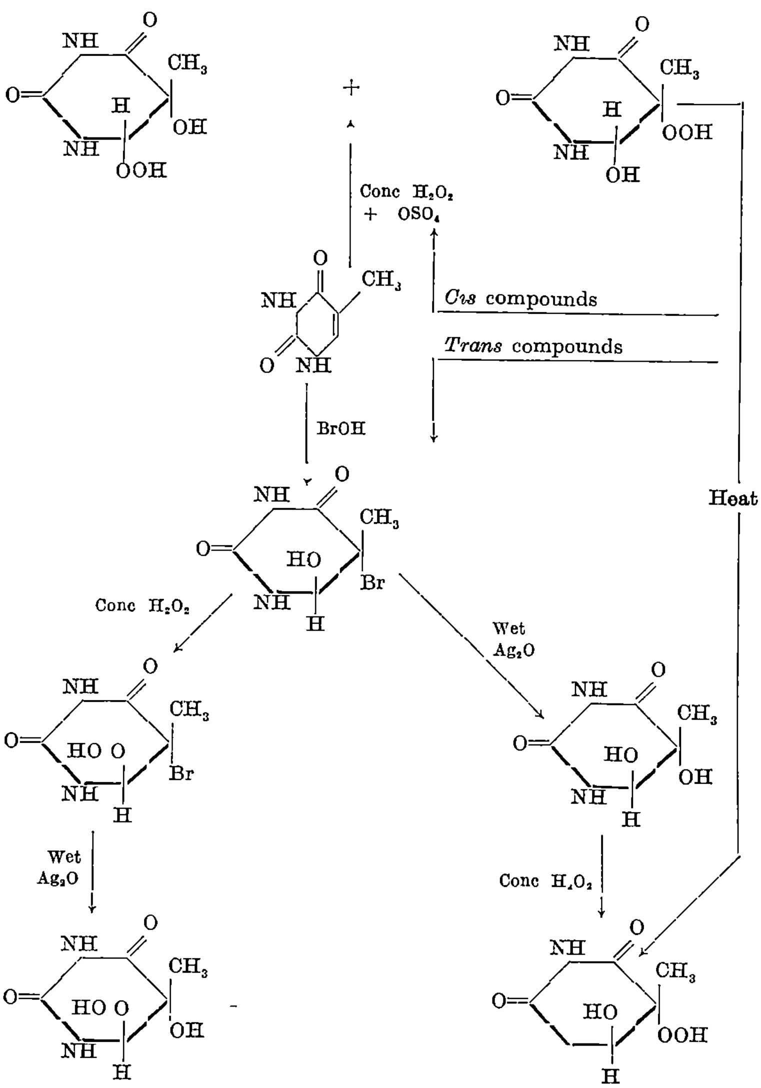
which are in agreement with previous preliminary results from this laboratory[2]. As the hydroperoxide produced by X-irradiation of thymine was sufficiently stable to permit isolation, the synthesis of compounds corresponding to formulæ I and II was attempted in order to compare them with the products isolated from X-irradiated thymine solutions. Each of these two compounds can presumably exist in two forms, *cis* and *trans*:


(I *cis*)


(I *trans*)


(II *cis*)


(II *trans*)



The *trans* compounds were separately synthesized from a common starting material *trans*-4-hydroxy-5-bromothymine, prepared by Jones's method[3]. Compound II *trans* was prepared by treatment of the starting material with hydrogen peroxide in dilute hydrochloric acid to give 4-hydroperoxy-5-bromothymine. Bromine was eliminated by shaking with silver oxide and centrifuging. The product was freed of the last traces of silver oxide by extraction with a chloroformic solution of dithizone. After lyophilization, the residue could be crystallized, with some difficulty, from acetone – petroleum ether. To give compound I *trans*, the starting material was transformed into 4,5-dihydroxythymine[4], which was then treated with hydrogen peroxide. After elimination of excess hydrogen peroxide by repeated lyophilizations, the residue could be crystallized from acetone–benzene. Compounds I *trans*, II *trans* and 4-hydroperoxy-5-bromothymine can easily be separated by paper chromatography, using *n*-propanol/1 *N* hydrochloric acid as a solvent (Table 1).

The treatment of thymine itself with hydrogen peroxide in the presence of catalytic amounts of osmium tetraoxide gives a mixture of two peroxidic compounds, which can be resolved by paper chromatography, giving spots with R_F 0.51 and 0.62 respectively. Since these two compounds do not behave on paper chromatograms like the *trans* hydroperoxides previously described, they probably are the *cis*

Table 1 PAPER CHROMATOGRAPHY OF HYDROPEROXIDIC DERIVATIVES OF THYMINE

Paper, Whatman No 1, solvent, *n*-propanol/1 *N* hydrochloric acid (85/15, v/v), temperature during run, 2° C

Compound		R_F
4-Hydroxy-5-hydroperoxythymine	*cis**	0 51
4-Hydroxy-5-hydroperoxythymine	*trans**	0 33
4-Hydroperoxy-5-hydroxythymine	*cis**	0 62
4-Hydroperoxy-5-hydroxythymine	*trans**	0 43
4-Hydroperoxy-5-bromothymine	*trans**	0 83
4-Hydrogen peroxide*		0 68
Thymine†		0 55

* Detected by spraying a 4 per cent alcoholic solution of potassium iodide

† Detected in ultra-violet light

compounds On heating a solution of the mixture, the product with R_F 0 51 is transformed into a product giving a spot with R_F 0 33, while the product with R_F 0 62 remains unchanged Accordingly, it may be suggested that the product with $R_F = 0$ 51 corresponds to formula II *cis*, as indicated in Table 1 These syntheses and the relationships between the compounds are summarized in the scheme on p 58

All the compounds can be reduced at the dropping mercury electrode in 0 1 *M* potassium sulphate at the same potential near 0 volt, against the saturated calomel electrode at 25° C They behave similarly on 'Dowex 50–H⁺' columns

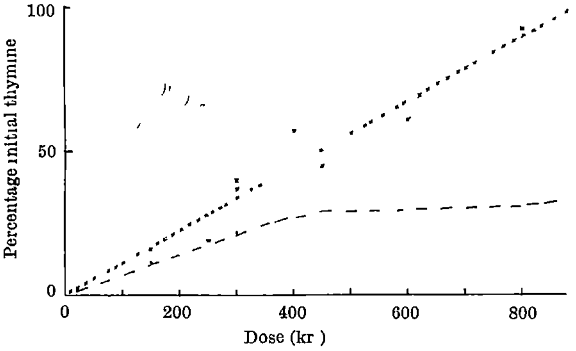


Fig 1 Destruction of thymine (—×—×—) and total production of hydroperoxide (— — —) by X-irradiation of a 10^{-3} M thymine solution by X-rays of 40 kV, filtered through 0 04 mm aluminium, dose, 25 kr, in air

In Fig 1 are shown the curves relating dose to thymine destruction and total hydroperoxide production, during X-irradiation in air A 10^{-3}-M solution of thymine, after irradiation with 400 kr, contained 2 1 × 10^{-5} M hydrogen peroxide and 1 9 × 10^{-4} M hydroperoxide After repeated lyophilizations, the residue was put on a 'Dowex 50-*X* 8' column, 1 cm × 50 cm, in 0 1 *N* hydrochloric acid The eluate was collected in 4-ml fractions Hydroperoxidic products, detected by the iodide reagent, appeared in fractions 5–11, and unchanged thymine in fractions 16–21 After paper chromatography and spraying with iodide reagent, material contained in fractions 5–11 gave a strong spot at the level of the spot given by compound I *cis* and a faint one at the level of the spot given by compound I *trans* Control chromatographs of various mixtures of synthetic peroxides and peroxides produced by X-irradiation demonstrated that the latter cannot be distinguished from the former with corresponding R_F's Therefore, it may be suggested that X-irradiation of thymine in aqueous aerated solutions actually produces hydroperoxides I *trans* and I *cis*

We wish to thank Dr R Laterjet for his interest throughout this work

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[1] Scholes, G, Weiss, J, and Wheeler, C M, *Nature*, 178, 157 (1956) Daniels, M, Scholes, G, Weiss, J, and Wheeler, C M, *J Chem Soc*, 226 (1957) Weiss, J, "Les peroxydes organiques en radiobiologie", 42 (Masson, Paris, 1958)

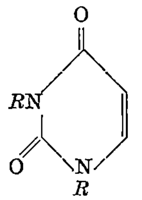
[2] Ekert, B, and Monier, R, *Ann Inst Pasteur*, 92, 556 (1957)

[3] Jones, W S, *Z physiol Chem*, 29, 20 (1899–1900)

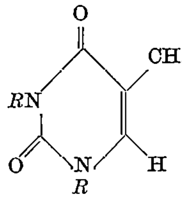
[4] Baudish, O, and Davidson, D, *Ber deut chem Ges*, 58, 1680 (1925)

Ultra-violet Irradiation of 1,3-Dimethylthymine

WHEN 5,6-unsubstituted pyrimidines (I) such as uracil, uridine and 1,3-dimethyluracil are irradiated with ultra-violet light, the absorption spectra gradually decrease with a simultaneous increase in end absorption These spectra can be reversed to the original by acid, alkali or heat[1]



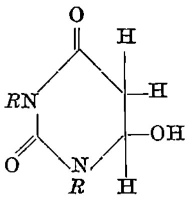
(I)



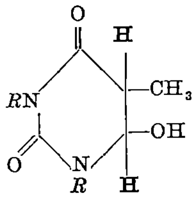
(II)

However, compounds substituted in the 5-position (II), such as thymine, thymidine and 1,3-dimethylthymine, do not show reversal under similar conditions Most investigators have suggested that this difference may be due to totally different photochemical reaction mechanisms in the two cases[2]

Upon close examination of these two groups of compounds it appears that they probably have the same electronic distribution, because the ketonic form as shown above is probably the common and predominant configuration in both[3]. Since the interaction with ultra-violet light is related to the electronic state of a compound, it is not unreasonable to assume that the initial step is similar for both groups of compounds



(IV)

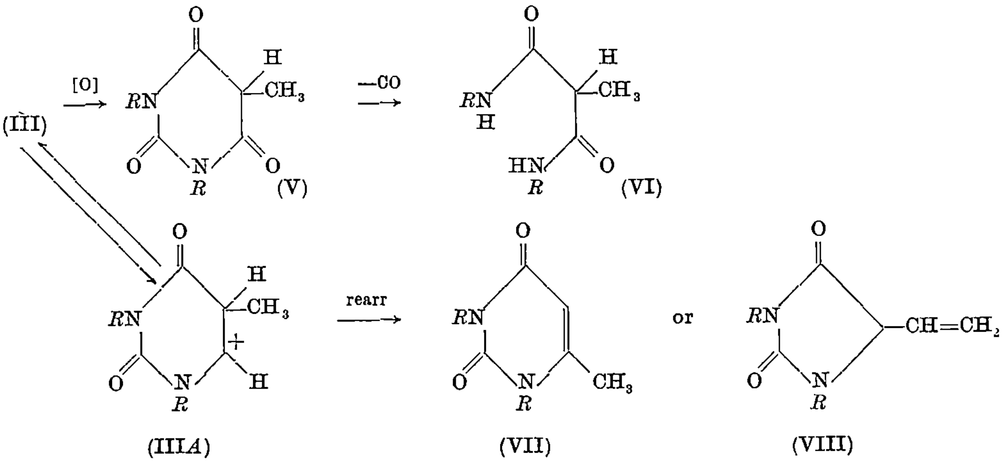


(III)

If the above assumption is true, then 6-hydroxyhydrothymines (III) would be expected as the first products, because 6-hydroxyhydrouracils (IV) have been shown to be the first products of the irradiation of uracils (I) [1] The reconstitution reactions of uracils were found to be dehydrations[1] For thymines, such dehydration would involve the much more reactive III°-H rather than the II°-H as in the uracils Therefore, the dehydration of III is probably much faster than the photo-addition of water to II. This reverse

$$\mathrm{II} \underset{-\mathrm{HOH}}{\overset{h\nu,\,\mathrm{HOH}}{\rightleftharpoons}} \mathrm{III}$$

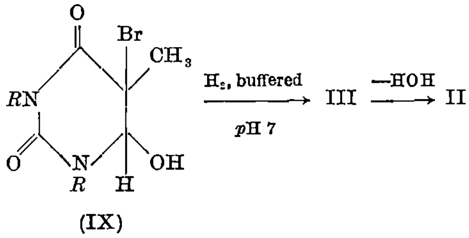
reaction would prevent the detection of III during and after irradiation, and would not be associated with a decrease in the absorption spectrum of II. Actually, however, this spectrum decreased with irradiation, and probably was due to further reactions of III to form irreversible compounds. For such reactions there are two possible routes:



If carbonium ions (III*A*) were formed from III, then through rearrangement either VII or VIII or both could be the products. If 'oxidation' were to occur, according to the route already established for uracils, then V would be the intermediate. Upon decarboxylation N,N′-dimethylmethylmalonamide (VI) would be the product[4].

In order to support experimentally the above arguments, the following two points would have to be demonstrated: first, the intermediate of hydration (III) must be shown to be much more unstable than that of 6-hydroxyhydrouracils (IV); second, one of the irradiation products via the intermediate (III) would have to be isolated.

We have used 1,3-dimethylthymine as a model compound. First, 5-bromo-6-hydroxy-1,3-dimethylhydrothymine (IX) was prepared and was reduced in a manner identical with that used for the preparation of 6-hydroxy-1,3-dimethylhydrouracil[1,5]. Examination of the ultra-violet spectrum of the reaction solution suggested that only 1,3-dimethylthymine was obtained as the product with little indication of the existence of 6-hydroxy derivatives.



(IX)

Upon hydrogenolysis of the 5-bromo-6-hydroxy derivatives of uracils, however, the following yields of 6-hydroxy derivatives were obtained in solution: from uridine, 40 per cent.; from 1,3-dimethyluracil, 80 per cent.; and from uracil, 30 per cent. Therefore, this suggested that III has a much greater tendency for dehydration than uracils have. Second, 1,3-dimethylthymine was irradiated in aqueous solution until a flat ultra-violet spectrum was obtained. The irradiation products were then separated and purified. One of the products has been identified as N,N′-dimethylmethylmalonamide (VI, m.p. 157–158° C. Found: C, 50.08; H, 8.39; N, 19.42. Synthetic VI, m.p. 157–158° C.; mixed m.p. with irradiation product 157–158° C. Found: C, 50.02; H, 8.25; N, 19.65. The infra-red spectra of synthetic VI and the irradiation product were identical.) On the basis of this evidence we would like to suggest that 1,4-addition of water to the thymine derivatives is the first step in the ultra-violet irradiation effect.

By examination of the quantum yields of the irradiation of thymine both in light and heavy water, Shugar has drawn the conclusion that the uptake of a water molecule is not involved[6]. From our findings it would appear that the measurements he made were actually of the subsequent slower steps and probably not for the initial fast reversible step.

Therefore, from the above findings, we have demonstrated that uracil and cytosine derivatives react similarly toward ultra-violet irradiation. This emphasized the fact that for the photochemical pathway of ultra-violet irradiation effects, the differences in electronic distributions of compounds are of more importance than the differences in their structures. They further suggest that the hydration product (III) may be of importance in photoreactivation reactions. Although the first irradiation products of uracils exhibit the phenomenon of reversibility, the irradiated uracils are stable under the customary photoreactivation conditions. Under biological conditions, however, the unstable initial thymine products (III) might be stabilized by secondary linkages, for example, H-bonds, in the nucleic acids. The H-bonds so formed could be broken by the usual photoreactivation conditions. Thus, thymines might be reconstituted and again show the biological activity of the original bases.

This work was carried out under the terms of Contract *AT*(30–1)911 of the Atomic Energy Com-

mission with the Physiology Department, Tufts University School of Medicine. I wish to thank M. Apicella and B. R. Stone for their able assistance.

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[1] Wang, S. Y., Apicella, M., and Stone, B. R., *J. Amer. Chem. Soc.*, 78, 4180 (1956). Wang, S. Y., *ibid.*, 80, 6196 (1958) and references therein.

[2] Sinsheimer, R. L., *Radiation Res.*, 1, 505 (1954). Wierzchowski, K. L., and Shugar, D., *Biochim. Biophys. Acta*, 25, 361 (1957). Rorsch, A., Beukers, R., Ijlstra, J., and Berends, W., *Rec. Trav. Chim.*, 77, 423 (1958).

[3] Marshall, J. R., and Walker, J., *J. Chem. Soc.*, 1004 (1951). Brown, D. J., Hoerger, E., and Mason, S. F., *J. Chem. Soc.*, 211 (1955).

[4] Wang, S. Y., *J. Amer. Chem. Soc.*, 80, 6199 (1958).

[5] Wang, S. Y., *Nature*, 180, 91 (1957); *J. Org. Chem.*, 24, 11 (1959).

[6] Shugar, D., and Wierzchowski, K. L., *Postepy Biochemii*, 4, II, 254 (1958).

Degradation of Thiotaurine by Ionizing Radiations

THE degradation of sulphur-containing compounds by ionizing radiation has been extensively studied[1-3] in view of the protective action of those compounds against radiation damage in animals. Recently, thiotaurine (aminoethylthiosulphonate) has become available for chemical and biological investigation[4,5]. Since thiotaurine was discovered as a metabolic product of cystine[6] and cystamine[7] in the rat, and since it is chemically related to cysteamine, it seemed of interest to study its reactivity towards irradiation with X-rays and γ-rays.

30 µmoles of pure thiotaurine dissolved in 3 ml. of water were placed in a glass vessel 2·5 cm. diameter. The solution was irradiated for a suitable length of time with a Philips 50 kV. X-ray source having a beryllium window. The shorter distance from the window to the centre of the solution was 1 cm. The intensity of irradiation was determined with a ferrous sulphate dosimeter[8]. 0·15 ml. of the solution was withdrawn for analysis at intervals.

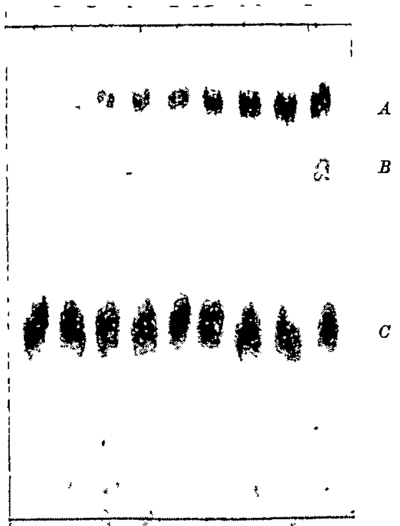

Fig. 1. Progressive chromatogram of the irradiated solution of thiotaurine with X-rays. Dose (r.), left to right, 0, 12,000, 36,000, 60,000, 84,000, 120,000, 240,000, 360,000, 480,000. Descending chromatogram in collidine–lutidine, developed with ninhydrin. 0·5 µmole of initial thiotaurine spotted at the starting line. *A*, hypotaurine; *B*, taurine; *C*, thiotaurine

As soon as irradiation started it became apparent that some reaction was taking place: the solution became more and more turbid. The degree of turbidity increased with the time of irradiation. The unirradiated control remained clear for a long time.

The material which caused turbidity was identified as colloidal sulphur by sedimentation in a 'Spinco' model *L* preparative ultracentrifuge at 125,000*g*, followed by conversion of the washed residue to thiocyanate by the procedure of Bartlett and Skoog[9].

Some of the compounds produced by the radiochemical degradation of thiotaurine have been detected by paper chromatography. At intervals a sample of the irradiated solution was spotted on a Whatman No. 4 filter paper and the chromatogram was run in collidine/lutidine/water (1:1:1 v/v) and developed with ninhydrin. Apart from a residue of unchanged thiotaurine, two main compounds reacting with ninhydrin appeared on the chromatogram. These have been identified, by careful comparison with the synthetic products and by specific reactions[6], as hypotaurine and taurine. Hypotaurine is the first degradation product to appear; its spot appears after a dose of 12,000 r. Taurine appears later and only in small amounts.

The production of hypotaurine and colloidal sulphur is consistent with the following overall reaction:

$$NH_2\text{—}CH_2\text{—}CH_2\text{—}SO_2SH \rightarrow NH_2\text{—}CH_2\text{—}CH_2\text{—}SO_2H + S$$

which represents the reversal of the reaction used for the synthesis of thiotaurine from hypotaurine and sulphur[4].

Essentially the same results have been obtained by irradiating a solution of thiotaurine with a comparable dose of γ-rays from a radium source immersed in the solution. The irradiation of a solution of thiotaurine buffered with phosphate *p*H 7·4 also gave identical results.

It is of interest that cystamine, one of the best known protective agents against radiation damage, under the same conditions and using the same procedure to detect degradation products, gave only a faint trace of taurine even with the higher doses of X-rays. In the light of these results the comparative effect of cystamine and thiotaurine in the radioprotection of animals is being studied.

This work has been assisted by a grant of the Comitato Nazionale Ricerche Nucleari.

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[1] Shapiro, B., and Eldjarn, L., *Radiation Res.*, 3, 255 (1955).

[2] Shapiro, B., and Eldjarn, L., *Radiation Res.*, 3, 393 (1955).

[3] Kopoldova, J., Kolousek, J., Babicky, A., and Liebster, J., *Nature*, 182, 1074 (1958).

[4] Cavallini, D., De Marco, C., and Mondovì, B., *Bull. Soc. Chim. Biol.*, 40, 1711 (1958).

[5] Sorbo, B., *Bull. Soc. Chim. Biol.*, 40, 1859 (1958).

[6] Cavallini, D., De Marco, C., and Mondovì, B., *J. Biol. Chem.*, 234, 854 (1959).

[7] Cavallini, D., De Marco, C., and Mondovì, B. (unpublished work).

[8] Weiss, J., Allen, A. O., and Schwarz, H. A., Geneva Conference on the Peaceful Uses of Atomic Energy, 14, 179 (1956).

[9] Bartlett, J. K., and Skoog, D. A., *Anal. Chem.*, 26, 1008 (1954).

GEOLOGY

The Geological Time-Scale

Recently Dr. K. I. Mayne, Dr. R. St. J. Lambert and D. York[1] proposed an extended geological time-scale which would place the middle of the Upper Cambrian at about 650 million years ago compared with 450 million years of the Holmes scale[2]. Their scale is based primarily on the ages they obtained by the potassium–argon method on biotite from several British granites; however, they cite many other age measurements for secondary support. It is the purpose of this communication to point out that most of the cases cited are either incorrect or not definitive to the argument. In addition, both they[1,3] and Prof. C. F. Davidson[3] refer at some length to our as yet unpublished isotopic study of the Swedish kolm. These comments contain errors of fact and interpretation which will be clarified by the full report which will appear elsewhere; but in view of the widespread misconception concerning this interesting material some discussion appears needed at this time. The British granites referred to above are being remeasured in this laboratory and results will be reported later.

First, concerning the alleged support of the extended time-scale:

(1) Mayne *et al.*[1] cite pitchblende measurements in the Upper Triassic Chinle formation of the Colorado Plateau by Miller and Kulp as indicating an age of about 210 million years. The published abstract[4] of the oral paper to which they refer does not imply this conclusion, and in the full published paper[5] Miller and Kulp discuss the problems involved and conclude that "The apparent (i.e., isotopic) ages bear no necessary relation to the actual time of deposition".

(2) Mayne *et al.*[1] incorrectly list a result of 360 million years from the Georgia Piedmont as being Permo-Carboniferous in age and refer to a paper by Kulp and Long. In the published abstract[6] the only reference to this area states "In the Southeastern Piedmont of Georgia there is evidence for a younger event occurring around 260 m.y. ago", but there was no attempt to make a stratigraphic assignment. In the oral presentation it was noted that there might be a correlation between this 260 million year metamorphic event and coarse sedimentation in the southernmost part of the Appalachian geosyncline during Carboniferous time; but it was emphasized that no direct stratigraphic correlation with the metamorphic rocks of the Georgia Piedmont is possible. A full report on the age work in the south-eastern Piedmont will appear elsewhere[7] shortly.

(3) The Beryl Mountain pegmatite is actually intruded into the pre-Silurian Ammonoosuc volcanics according to Kruger[8], and not the lower Devonian Littleton formation. Even if the pegmatite were intruded at the time of metamorphism of the Littleton formation as assumed by Damon and Kulp[9], there is no stratigraphic reason for suggesting a Carboniferous age as is done by Mayne *et al.*

(4) The samples of feldspar (Dubuque formation and Mynydd Mawr granite) and sylvite give only minimum ages. The retention of argon in these materials has not been sufficiently well defined to use them for quantitative age determination. Mayne *et al.*[3] in their latest communication agree that little importance should be attached to these dates.

(5) The Boisdale Hills granite, according to the latest geological information (Hurley, personal communication), is not intimately related to the fossil sequence; but presumably the same or a similar granite less than one mile away intrudes a sedimentary sequence dated as Middle Cambrian to Lower Ordovician. The age of 490 million years is therefore much more likely to be a minimum for Lower Ordovician rather than being post-Lower Devonian as Mayne *et al.*[1] state.

(6) The post-Lower Devonian intrusives in both Nova Scotia and Maine as measured by the Massachusetts Institute of Technology group[10] give ages which group at about 365 million years, not 400 million years as used by Mayne *et al.*[1]

(7) The errors on the rubidium–strontium ages on bentonites are too large to allow the ages to be definitive. The Adams *et al.*[11] report was only preliminary, and further work needs to be done before the apparent ages on bentonites can be properly interpreted.

In their reply to Prof. Davidson, Mayne *et al.*[3] correctly reject those points cited by Prof. Davidson as evidence against their extended scale where "either the stratigraphy of the sample or their measured age is not free from unwarranted assumptions". In the above discussion, these same criteria have been used to evaluate the dates and localities used in the first report by Mayne *et al.*[1] as support for their expanded time-scale. The Russian measurements on mica from pebbles in Lower Cambrian rocks, as reported by Davidson[3], cannot be dismissed so easily as Mayne *et al.*[3] have done. If the measurements have been properly made and the minerals have not been altered since, the results are significant. The two pebbles which give isotopic ages of 566 and 763 million years could represent rocks of different real ages. In this case, the younger age would set an upper limit on that part of the Lower Cambrian. It is concluded that the evidence for the extended time-scale lies almost entirely with the measurements made by Mayne *et al.*[1] on the Shap, Cairnsmore and Land's End granites.

The extensive consideration which Mayne *et al.*[1] and Davidson[3] gave the kolm in the Upper Cambrian Swedish black shale is illustrative of the importance of the age of this formation in establishing a time-scale. More than twenty kolm samples from this formation collected over a wide geographical area have been analysed in this laboratory. The isotopic uranium–lead ages are grossly discordant and vary from sample to sample[12]. The detailed interpretation and discussion of these apparent ages are being prepared for publication in another journal[13]. From these measurements it has been concluded that the discordance among the isotopic ages is caused by a combination of bulk lead loss and additional preferential loss of lead-206 due to migration of an intermediate member in the uranium-238 decay chain during the history of the mineral. On this basis, an analysis of the data indicates a minimum age for this formation of about 500 million years. The complexity of the leaching processes occurring is such that a maximum age cannot be assigned solely on the basis of the isotopic data. Mayne *et al.*[1] attribute to us the statement, "They believe the true age to be no greater than 550 m.y." This does not correspond to our opinion, and the reference they cite does not contain this statement. The evidence points to the minimum age as being nearly correct, but there is no unique solution of the data.

Davidson's[3] discussion of the meaning of the kolm ages is erroneous. He mentions that the formation contains old radiogenic lead. Our data strongly indicate that the lead incorporated in the black shale at the time of its deposition was normal in its isotopic composition. His hypothesis that uranium has been continuously introduced into the kolm by percolating ground water is not supported by the observed distribution of uranium in the kolm. Further, it should be pointed out that the effect on the isotopic ages due to introduction of uranium is indistinguishable from that due to loss of lead. Therefore, even if this hypothesis were adopted it would not cause any revision in the interpretation that the minimum age of the kolm is about 500 million years. Davidson's deduction that the formation is necessarily younger than 650 million years since this is the lowest lead-207–lead-206 age is not valid. The meaning of this age is directly dependent on the nature of the chemical alteration that occurred.

The current investigations in a number of laboratories on the age of stratigraphically well-defined rocks will permit a much closer definition of the geological time-scale in the near future. The extended scale proposed by Mayne *et al.*[1] is based on limited data and is not supported by measurements other than their own.

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[1] Mayne, K. I., Lambert, R. St. J., and York, D., *Nature*, 183, 212 (1959).

[2] Holmes, A., *Trans. Geol. Soc. Glasgow*, 21, 117 (1947).

[3] Davidson, C. F., *Nature*, 183, 768 (1959). Mayne, K. I., Lambert, R. St. J., and York, D., *Nature*, 183, 769 (1959).

[4] Miller, D. S., and Kulp, J. L., *Trans. Amer. Geophys. Union*, 39, 525 (1958).

[5] Miller, D. S., and Kulp, J. L., *Econ. Geol.*, 53, 937 (1958).

[6] Kulp, J. L., and Long, L. E., *Trans. Amer. Geophys. Union*, 39, 522 (1958).

[7] Long, L. E., Kulp, J. L., and Eckelmann, F. D., *Amer. J. Sci.* (in the press).

[8] Kruger, Fredrick C., *Geol. Soc. Amer. Bull.*, 57, 161 (1946).

[9] Damon, P. E., and Kulp, J. L., *Amer. J. Sci.*, 255, 697 (1957).

[10] Hurley, P., *et al.*, Atom. Energy Comm. Rep. *NYO* 3938 (December 1958).

[11] Adams, J. A. S., Edwards, G., Henle, W., and Osmond, K., *Geol. Soc. Amer. Bull.*, 69, 1527 (1958).

[12] Cobb, J. C., and Kulp, J. L., *Geol. Soc. Amer. Bull.*, 69, 1547 (1958).

[13] Cobb, J. C., and Kulp, J. L. (to be submitted to *Geochim. et Cosmochim. Acta*).

Palæomagnetism and Rotation of Newfoundland

Nairn, Frost and Light have recently reported[1] on the palæomagnetic results from Carboniferous and Pre-Cambrian rocks of Newfoundland. By comparing their Carboniferous results with results obtained by other workers[2] in the western United States they show that Newfoundland may have been rotated 20° anticlockwise since Carboniferous time.

I wish to report some results obtained from Carboniferous rocks of New Brunswick and the Gaspé Peninsula, which, with the results of Nairn *et al.*, show that no relative rotation between Newfoundland and these areas has occurred since Carboniferous times. Therefore, if the proposed rotation of Nairn *et al.* is correct, New Brunswick, the Gaspé Peninsula and Newfoundland must have rotated as a unit.

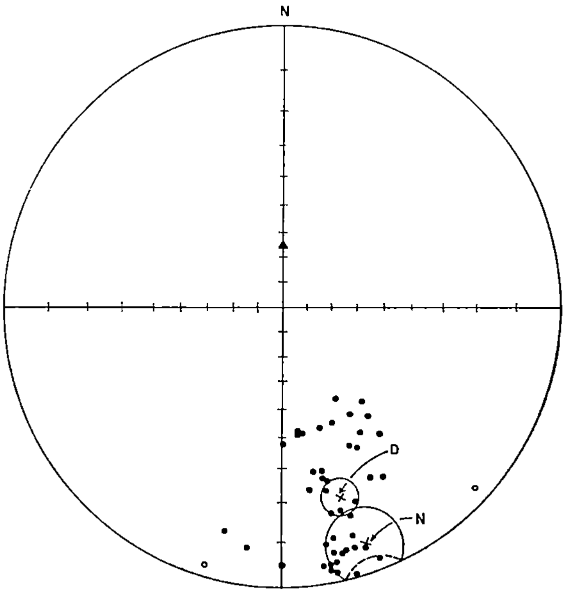

Fig. 1. Directions of magnetization measured in Carboniferous rocks of the Canadian Maritime Provinces. ●, Directions of magnetization of my samples, north pole on lower hemisphere; ○, directions of magnetization of my samples, north pole on upper hemisphere; $X \leftarrow D$, mean direction of my samples (with circle of confidence at Fisher's 95 per cent level of probability); $X \leftarrow N$, mean direction of samples of Nairn *et al.* (with circle of confidence at Fisher's 95 per cent level of probability); ▲, direction of magnetic field produced by a central axial dipole oriented along the Earth's present axis of rotation.

In the summer of 1958 twenty-two samples of the Bonaventure formation (Upper Mississippian or Lower Pennsylvanian) were collected by me from the south shore of the Gaspé Peninsula, Province of Quebec, between Percé and Maguasha. Fourteen samples were also collected from the Kennebecasis formation of Mississippian age at localities about fifteen miles north-east of St. John, New Brunswick. Ten samples were collected by Dr. C. H. Stockwell in the autumn of 1955 from the Pennsylvanian Bathurst formation near Bathurst, New Brunswick. Two 1-in. cubes were cut from each of these samples and were measured on the astatic magnetometer of the Dominion Observatory, Ottawa. The mean direction of each sample has been plotted on a stereogram in Fig. 1. Since rocks were collected from an extensive area, their directions have been corrected to the geographical location 48° N. and 66° W. by assuming that the Earth's average magnetic field is a dipole. The mean direction of the results of Nairn *et al.* from the Codroy gypsum also has been corrected to 48° N. and 66° W. and plotted on Fig. 1.

By inspection one can see that there is no significant difference between the declinations of the Newfoundland samples and of those reported here. This surmise is confirmed by Fisher's statistical analysis which gives a mean direction, corrected to 48° N. and 66° W., of $D = 160·5°$ and $I = +6·0°$ with a circle of confidence of 8·4° for the samples of Nairn *et al.*, and a mean direction of $D = 163·5°$ and $I = +19·5°$ with a circle of confidence of 5·0° for my samples. Thus, there is no significant difference between the two directions, and there is no evidence for any relative rotation between Newfoundland and the mainland Maritime Provinces, since Carboniferous time.

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[1] Nairn, A E M , Frost, D V , and Light, B G , *Nature*, 183, 596 (1959)

[2] Creer, K M , Irving, E , and Runcorn, S K , *Proc Roy Soc* , A, 250, 144 (1957)

BIOCHEMISTRY

Kinetic Study of Dextransucrase based on the Langmuir Adsorption Isotherm

THE action of the polysaccharide-synthesizing enzyme dextransucrase has been described previously in terms of *p*H [1] and the effect of various alternate receptors[2,3] We have now examined the dependence of rate of reaction on the concentration of enzyme The results are interpreted on the basis of adsorption kinetics[4], where the substrate (sucrose) and acceptor are adsorbed simultaneously on adjacent sites of the enzyme This is followed by glucosyl transfer from sucrose to acceptor No reaction occurs between bound sucrose and acceptor in solution, and there is no separate hydrolytic step prior to the transfer of the glucosyl group

The kinetic studies were carried out by exposing sucrose solutions to varying amounts of crude enzyme solution at 25° C and *p*H 5 2, and measuring the amount of fructose produced at a given time The enzyme was prepared as reported elsewhere[1] Sucrose solution (0 2 ml of a 0 01 *M* solution in 0 05 *M* acetate buffer *p*H 5 2) was incubated with 0 02–1 6 ml of the enzyme solution (assaying 49 units/ml) and buffered to make a final volume of 1 8 ml After ½ hr the reaction was quenched with 0 1 *M* sodium hydroxide and the reducing sugars determined colorimetrically[5,6] A plot of rate against enzyme concentration is shown in Fig 1

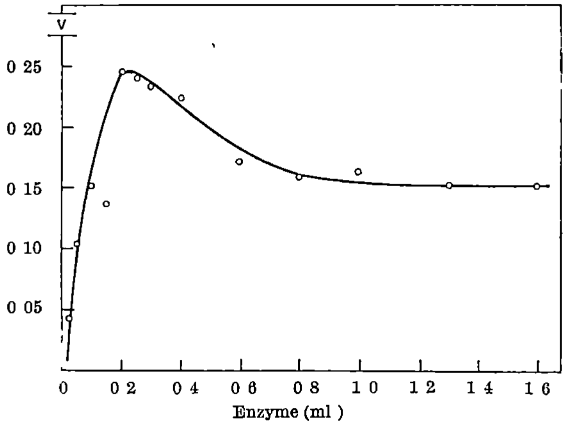

Fig 1 Plot of initial velocity (mgm fructose/1 8 ml /½ hr) against enzyme concentration

The appearance of a maximum in such a plot is rare, however, it has been reported for the lactic dehydrogenase system[7] Laidler and Socquet[4] have treated this case theoretically and have derived the following rate equation :

$$v = \frac{kK_1K_2[E]_0[S_1]_0[S_2]_0}{\{1+[E]_0(K_1+K_1')+K_1[S_1]_0+K_1'[S_2]_0\}\{1+[E]_0(K_2+K_2')+K_2'[S_1]_0+K_2[S_2]_0\}} \quad (1)$$

where k is the rate constant for the decomposition of the complex , S_1 and S_2 are the two substrates, in this case sucrose and acceptor , K_1 and K_2 are the corresponding equilibrium constants for the formation of the binary complex , K_1' and K_2' are the equilibrium constants for the cross adsorption of S_2 on site 1 and S_1 on site 2 respectively It is seen that equation (1) predicts linearity of rate against enzyme or sucrose at low concentration, but an inverse relationship and hence a maximum at high concentration

At high enzyme concentration, the substrates are spread out over a large number of enzyme sites The observed decrease in rate is attributed to the decreased probability that adjacent sites will be occupied in these circumstances The previously observed maximum in the rate against sucrose concentration[8] indicates that sucrose is cross-adsorbed on the acceptor sites (which may well be identical with the donor sites) and thus inhibits the reaction Attempts to observe maxima in S_2 by adding alternate acceptor have been complicated by the presence of the natural acceptor Thus far, only a roughly linear increase of rate with acceptor concentration has been observed

If a reaction were occurring between bound substrate and unbound acceptor, no maximum would occur Furthermore, it has been shown[4] that in cases where one substrate is solvent there is no maximum in the enzyme curve Hence the possibility of a hydrolytic reaction with sucrose followed by a rate-determining combination with dextran is eliminated The presence of the observed maxima thus fits only the case of simultaneous two-substrate adsorption

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[1] Neely, W B , *J Amer Chem Soc* , 80, 2010 (1958)

[2] Koepsell, H J , Tsuchiya, H M , Hellman, N M , Kazenko, A , Hoffman, C A , Sharpe, E S , and Jackson, R W , *J Biol Chem* , 200, 793 (1952)

[3] Bailey, R W , Barker, S A , Bourne, E J , Grant, P M , and Stacey, M , *J Chem Soc* , 1895 (1958)

[4] Laidler, K J , and Socquet, Irene M , *J Phys and Coll Chem* , 54, 530 (1950)

[5] Somogyi, M , *J Biol Chem* , 160, 61 (1945)

[6] Nelson, N , *J Biol Chem* , 153, 375 (1944)

[7] Socquet, Irene M , and Laidler, K J , *Arch Biochem Biophys* , 25, 171 (1950)

[8] Neely, W B , *Nature*, 182, 1007 (1958)

Agar Electrophoresis of Normal Soluble Proteins in Guinea Pig Liver

HITHERTO, neither free electrophoresis[1] nor electrophoresis on filter paper of the soluble proteins in liver (ref 2, and Smetana, R , and Kořínek, J , personal communication) has afforded satisfactory delimitation of a sufficient number of fractions After obtaining a number of unsatisfactory results on filter paper, we turned our attention to electrophoresis on agar gel

Healthy guinea pigs weighing between 300 and 900 gm were lightly anæsthetized with ether before being perfused with normal saline The liver was ground in a mortar with quartz sand 1–3 ml of a 0 7 per cent solution of sodium chloride (the amount depending on the size of the liver) was added and the whole stored in a refrigerator 24 hr later it was centrifuged at 6,000 r m p for 2–3 hr

Table 1

Fraction	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*
Average percentage value (*M*)	2 1	6 1	7 1	4 7	4 1	5 5	10 1	19 7	32 5	5 2	1 6	0 6	0 7
Standard deviation (σ)	±0 7	±1 8	±2 1	±1 4	±1 1	±1 6	±2 2	±5 2	±6 7	±1 5	±0 5	±0 3	±0 2

The liquid layer, situated beneath the superficial layer of lipids, was used for the electrophoresis itself

For the agar electrophoresis we used Ilkov and Nikolov's version (personal communication) of Grabar's technique, slightly modified Instead of Grabar's original cuvettes, we used our ordinary containers for paper electrophoresis[3] with platinum electrodes

The dimensions of the glass plate were 23 5 cm × 11 5 cm The agar is poured on a plate, which was held horizontally in 'Plexiglass' frames pressed against the plate itself Double strips of filter paper were previously placed along the two shorter sides of the plate The agar layer was 3 mm thick (45 cm ^{3} for each plate) Three grooves (2 cm × 1 mm) were cut from each plate and their bottoms carefully covered with diluted agar (0 30–0 50 per cent) Dittmer's[4] veronal–sodium acetate buffer (pH 8 6, $\mu = 0$ 06) was used The ionic strength of the buffer in the agar gel was half that in the chamber A sheet of filter paper was placed in contact with the underside of the plate, the ends of the sheet being dipped in water in order to cool the plate During electrophoresis the 'Plexiglass' frame is covered with a glass plate which is turned every 20–30 min A spread of 10–12 cm was recorded after a 5-hr migration at 180–200 V by staining with amido-black 10*B* The electropherograms were scanned with the Zeiss extinction registrator II

Livers of 21 experimental animals were investigated Except in a few cases, two parallel electropherograms were run in each case

Thirteen well-defined fractions were established These were designated with the letters *a* to *m*, beginning with the globulin fractions and ending with the albumin fraction (Figs 1 and 2, Table 1)

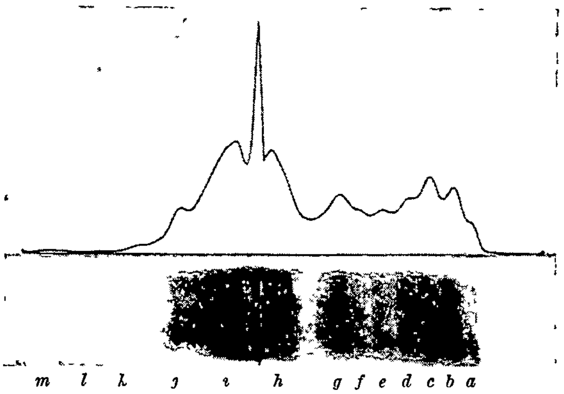

Fig 1

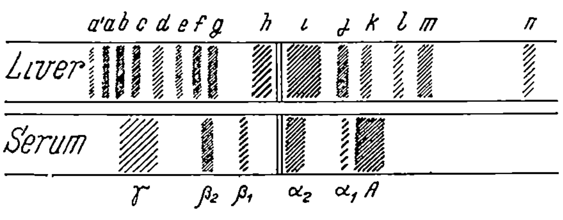

Fig 2

We preferred to label these fractions in the direction opposite to that which is customary because the initial globulin fractions were the best defined Fraction *a* is situated a little behind the γ-globulin, whereas fractions *l* and *m* are in front of the albumins of the blood serum

The interrelations between the remainder of the hepatic fractions observed and the protein fractions of the blood serum can be seen in Fig 2 Fractions *k*, *l* and *m* occur in negligible quantities and are often scarcely established Fraction *i* in Fig 1 is not sharply delimited from fraction *h* In other cases it was clearly delimited, so that its existence is out of doubt A separate fraction migrating beyond fraction *a* (fraction *a'*) was established in certain cases In one instance, we found a fraction migrating faster than fraction *m* (fraction *n*) With these, the total number of fractions observed by us was 15 In view of the fact that fraction *i* is not clearly delimited, however, it is probably composed of a few subfractions It is possible that this may be the case with fraction *h* also Thus the actual number of soluble hepatic protein fractions may be still greater

The average percentage values for the different fractions and the average standard deviations of their respective variation lines are given in Table 1

A few of the electropherograms were tested for lipoproteins by staining with 'Fettrot'–7–*B* Ciba[3] A small amount of lipoprotein could be detected in fraction *i* only

Thus our results show that, in the separation of soluble hepatic proteins, agar electrophoresis has certain advantages as compared to free electrophoresis and to electrophoresis on paper

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[1] Sorof, S , and Cohen, P P , *J Biol Chem* , **190**, 311 (1951) Demling, L , Kinzlmeier, H , and Henning, N , *Z Exp Med* , **122**, 416 (1954) Kaplanski, S I , Kuzovleva, O B , Uspenskaia, V D , *Biokhimia*, **21**, 469 (1956) Kaplanski, S I , Gourevitch, A E , and Staroselceva, L K , *ibid* , **23**, 114 (1958) Smetana, R , and Kořínek, J , *Cs gastroenterologie*, **10**, 208 (1956)

[2] Adjutantis, G , *Nature*, **173**, 539 (1954) , **174**, 1054 (1954)

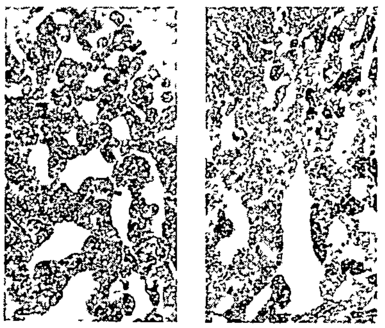
[3] Todorov, Y , and Karakashev, A , *Savremena meditsina*, **6**, 78 (1956)

Dittmer, A , "Papierelektrophorese" (1956)

Abolition by Chlorpromazine of the Inhibiting Effect of Iproniazid on the Depletion of Adrenal Catechol Amines induced by Reserpine

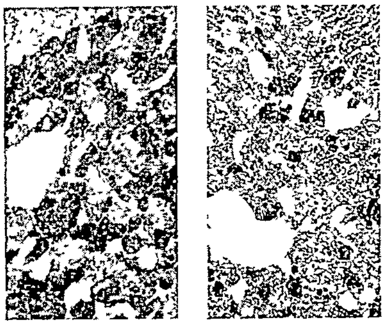
It is well known that reserpine induces a decrease of catechol amines in the adrenal medulla[1–5] In the rat pretreatment with iproniazid, a monoamine oxidase inhibitor, completely overcomes this catechol amine depletion[6–8]

In the present study the modifications of the catechol amine content of the adrenal gland have



(*a*) (*b*)

Fig 1 Adrenal medulla of rat Chromaffin reaction (*a*) A normal degree of chromaffinity is detected in all cells after administration of iproniazid and reserpine (*b*) After administration of chloropromazine in association with iproniazid and reserpine numerous islets of cells completely devoid of chromaffin material are observed (× 44)



(*a*) (*b*)

Fig 2 Adrenal medulla of rat Chromaffin reaction After association of chlorpromazine to the reserpine (*b*), a higher number of chromaffin-negative cells is observed compared to that detected after administration of reserpine alone (*a*) (× 44)

been investigated when chlorpromazine is added together with reserpine and iproniazid

40 male albino rats, Wistar stock, weighing approximately 250 gm were divided into five groups Animals of the first three groups were treated respectively with (1) iproniazid (100 mgm /kgm); (2) chlorpromazine (20 mgm /kgm), (3) chlorpromazine (20 mgm /kgm) and iproniazid (100 mgm / kgm) After 5 hr all the animals were given reserpine in a dose of 1 mgm /kgm The animals of the remaining two groups were treated with chlorpromazine only (20 mgm /kgm) or with reserpine only (1 mgm /kgm) The drugs were injected intraperitoneally Animals were killed by decapitation 24 hr after the last injection The adrenal glands were removed immediately after death and then treated with a potassium dichromate–chromate solution

In the adrenals of rats treated with reserpine the chromaffin reaction shows many groups of cells completely devoid of positive granules irregularly distributed through the normally stained parenchyma (Fig 2*a*) On the other hand, in the rats treated with iproniazid and reserpine, all the cells of the adrenal medulla show a positive chromaffin reaction similar to that observed in the normal gland (Fig 1*a*)

The administration of chlorpromazine and iproniazid before reserpine causes consistent changes as compared with the findings observed after the administration of iproniazid and reserpine alone In these circumstances several groups of cells completely devoid of chromaffin material can be detected (Fig 1*b*), moreover, the number of the non-chromaffin cells is considerably larger than in glands of animals treated with reserpine alone Similar results were obtained for the adrenals of rats treated with reserpine and chlorpromazine (Fig 2*b*) Chlorpromazine alone does not cause any significant changes in the chromaffinity of the medullar cells

These results demonstrate that the inhibiting effect of iproniazid on the adrenaline and noradrenaline depletion induced by reserpine can be abolished by chlorpromazine, moreover, this substance alone does not deplete the catechol amines of the adrenal medulla Since chlorpromazine also increases the depletion of catechol amines following reserpine administration, one could assume that this drug can not only protect the monoamine oxidase from the inhibitory effect of iproniazid but also increases the enzyme activity

We wish to thank Prof G C Dogliotti for his very helpful criticism in this investigation

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[1] Carlsson, A , and Hillarp, N A , *Kungl Fysiogr Sallsk Lund Forh* , **8**, 26 (1956)

[2] Kroneberg, G , and Schumann, H J , *Arzneimittelforschung*, **4**, 279 (1957)

[3] Molinatti, G M , Camanni, F , and Losana, O , *Arch Int Pharmacodyn* , **116**, 483 (1958)

[4] Camanni, F , Losana, O , and Molinatti, G M , *Experientia*, **4**, 199 (1958)

[5] Camanni, F , and Molinatti, G M , *Acta Endocrinol* , **29**, 369 (1958)·

[6] Holtz, P , Balzer, H , and Westermann, E , *Arch Exp Path Pharmak* , **231**, 361 (1957)

[7] Zbinden, G , and Studer, A , *Experientia*, **14**, 201 (1958)

[8] Camanni, F , Losana, O , Molinatti, G M , and Olivetti, M , *Arch Int Pharmacodyn* (in the press)

Destruction of Carotenoids in Isolated Chloroplasts

Booth[1] has recently directed attention to the various mechanisms which are responsible for carotenoid destruction in green tissues, two of which, a photochemical reaction and an enzymic reaction, have been examined in alfalfa leaf macerates[2] Enzymic destruction of β-carotene is reported to be greatest in plant tissues containing chlorophyll[1], and we have therefore made a preliminary examination of the destruction of endogenous carotenoids in isolated chloroplast suspensions prepared from leaves of spinach beet.

Leaves were ground at −1° C in a medium consisting of 0 5 *M* sucrose, 0 067 *M* phosphate buffer (*p*H 7 3), and 0 01 *M* potassium chloride Whole cells and debris were removed by centrifugation at 200*g* for 1 min , chloroplasts were sedimented by centrifugation at 1,000*g* for 10 min , washed once, and re-sedimented before final resuspension in the medium Carotenoids were extracted from the chloroplasts with acetone, separated chromatographically and estimated spectrophotometrically[3] The destruction of carotenoids in the chloroplasts was measured by comparing the amounts present before and after reaction

In order to separate the effect of light from that of heat on the destruction of carotenoids, the experiments on illuminated preparations were carried out at 16° C with illumination from a 100-watt incandescent lamp with a water-cooled condenser For the dark controls, tubes were covered with aluminium foil

When non-aerated chloroplast suspensions were illuminated, 6 per cent of the β-carotene disappeared in 30 min , compared with 4 per cent in the dark Since none disappeared in boiled suspension the reaction was probably enzymic Bubbling air through the chloroplast suspensions increased the light-catalysed destruction of β-carotene to 27 per cent, while in the dark 14 per cent disappeared The relative rates of disappearance of the individual carotenoids were β-carotene > violaxanthin ≫ lutein , the last only started disappearing after 1 hr The order of disappearance of these carotenoids is the same as that of the disappearance of carotenoids in autumn leaves[4]

The addition of Hill reaction oxidants to spinach beet chloroplast suspensions gave varying results 2,6-Dichlorophenol indophenol[5] reduced the destruction of β-carotene in non-aerated chloroplast suspensions to 2 per cent (controls 6 per cent), whereas ferric oxalate–potassium ferricyanide solution[6] increased the destruction to 19 per cent The ferric oxalate–potassium ferricyanide solution had no effect on the destruction of β-carotene in the presence of light and air, but when coupled with the addition of phenazine methosulphate[7] there was measurable inhibition of carotene destruction β-Carotene destruction was stimulated by the addition of *ortho*-phenanthroline[8] to the ferric oxalate–potassium ferricyanide solution in the presence of light and air When zinc acetate[8] was also added, there was a further increase of β-carotene destruction This result was contrary to expectations since zinc acetate reverses the inhibitory effect of *o*-phenanthroline on the Hill reaction[8]

Further experiments on non-illuminated preparations were carried out in which leaf preparations were shaken in a water-bath at 30° C in the dark The activity of chloroplasts from different batches of leaves varied considerably , in some chloroplast preparations 20 per cent of the β-carotene disappeared, whereas in others 50 per cent disappeared, after 1 hr

The enzymic destruction of carotene in chloroplasts in the dark at 30° C was inhibited by phenazine methosulphate *o*-Phenanthroline had no effect, but, in the presence of zinc acetate, *o*-phenanthroline greatly stimulated carotene destruction These effects are somewhat comparable to those found in the light-catalysed destruction and suggest some similarity between the two processes

In an attempt to locate the enzymic system responsible for destruction of β-carotene, a comparison was made of the disappearance of β-carotene in leaf homogenates, chloroplasts prepared from them, and the supernatant fraction which still contained broken chloroplasts In spinach beet leaves there was an almost equal destruction in all three fractions, suggesting that the enzyme system responsible for the destruction was closely linked to the pigment–protein complexes In sugar beet leaves, however, there was more destruction of β-carotene in both the homogenate and the supernatant than in the chloroplast fraction This could be due to the fact that in sugar beet leaves there are at least two differently located enzyme systems responsible for carotene destruction, which would be in accord with more recent findings (Friend, J , and Mayer, A M., unpublished work)

The work described in this communication was carried out as part of the programme of the Low Temperature Research Station of the Department of Scientific and Industrial Research

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[1] Booth, V H , *Qualitas Plantarum*, 3/4, 317 (1958)

[2] Walsh, K A , and Hauge, S M , *J Agric Food Chem* , 1, 1001 (1953)

[3] Friend, J , and Nakayama, T O M , *Analyst* (in the press)

[4] Goodwin, T W , *Biochem J* , 68, 503 (1958)

[5] Holt, A S , and French C S , *Arch Biochem* , 19, 368 (1948)

[6] Vishniac, W , in "Methods in Enzymology", edit by Colowick, S P , and Kaplan, N O , 4, 342 (Academic Press, New York, 1957)

[7] Jagendorf, A T , and Avron, M , *J Biol Chem* , 231, 227 (1958)

[8] Warburg, O , and Lüttgens, W , *Biokhimiya*, 11, 303 (1946)

Use of Porter–Silber and Schiff Reagents as Spot Tests for Steroids applied on Paper and their Application to the Study of Rat Adrenal Lipids

THE formation of phenylhydrazones with an absorption maximum at 410 mμ by the method of Porter and Silber characterizes steroids with a dihydroxyacetone side-chain These authors recently reported that the reaction also occurred with the aldehydes of corticosterone and of 11-dehydrocorticosterone and that with the latter compounds the phenylhydrazone developed at a more rapid rate[1] The specificity and difference in speed of the reaction are also evident when it is carried out on paper. A bright yellow colour develops when a region containing a minimum of 2 μgm /cm ^{2} of the chromogen is passed through the Porter–Silber reagent (25 ml water, 41 ml conc sulphuric acid, 34 ml ethyl alcohol and 43 mgm. phenylhydrazine hydrochloride) The colour appears instantly with C-21 aldehydes and their acetates, and in 1–2 hr with steroids containing the dihydroxyacetone side-chain and their acetates It is stable for days provided the paper is not rinsed or warmed, and under these conditions the paper does not char Corticosterone, 17-hydroxyprogesterone and other steroids tested gave no colour at a concentration of 25 μgm /cm ^{2}

C-21 aldehydes, freshly prepared by oxidation with cupric acetate after the method of Beyler and Hoffman[2], may be detected with a Schiff reagent (1 per cent pararosaniline hydrochloride in sulphurous acid), if 10 μgm have been applied over an area of 1 cm ^{2} A purple colour appears as the rest of the paper turns pink The development of the same purple colour in the rest of the paper may be delayed for a few days by encasing the paper in 'Scotch' tape Steroids with an α-ketol- and a dihydroxy-acetone side-chain gave no reaction in amounts of 50 μgm /cm ^{2}, neither did a sample of aldosterone kindly supplied by Merck and Co It is to be noted that freshly prepared aldehydes react at a lower concentration than material which has been stored in the refrigerator or chromatographed in the toluene–propylene glycol system

Both tests have proved helpful in the synthesis and purification by paper chromatography of steroid C-21 aldehydes When a region on paper gave a positive reaction to the two tests and failed to reduce a tetrazolium derivative, the presence of an aldehyde was assumed

The sensitivity and simplicity of the Porter–Silber spot-test should make it a useful tool for the detection of Porter–Silber chromogens in lipid extracts of biological fluids The test has helped in establishing the facts that the incubated rat adrenal secretes little, if any, cortisol or cortisone[3], that the non-reducing, lipid-soluble Porter–Silber chromogen produced by this tissue has the same mobility in the toluene–propylene glycol system as the aldehyde of 11-deoxy-17-hydroxycorticosterone, and that acetylation of the adrenal lipid yields two ultra-violet-absorbing, non-reducing Porter–Silber chromogens, a component with the same mobility in the benzene-formamide system as a product obtained by acetylation of 11-deoxy-17-hydroxycorticosterone aldehyde, and a more polar material[4]

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[1] Silber, R H, and Porter, C C, in "Methods of Biochemical Analysis", 4, 139 (Interscience Publishers, Inc, 1957)

[2] Beyler, R E, and Hoffman, F, *J Amer Chem Soc*, 79, 5297 (1957)

[3] Birmingham, M K, and Kurlents, E, *Can J Biochem Physiol*, 37, 510 (1959)

[4] Ward, P, and Birmingham, M K (in preparation)

Some Observations on Certain Mucoproteins containing Neuraminic Acid

IT is now well established[1–4] that mucoproteins, particularly those containing neuraminic acids, play a major part in the natural defences of the human body With the object of determining what part is played by such mucoproteins in human cancer we have assessed the amount and distribution of mucoproteins containing neuraminic acid by determination of the neuraminic acid content of tissues obtained in surgical operations for cancer of the stomach, colon and breast, and compared these with those of tissues obtained during removal of ulcers of the stomach and duodenum

Each portion of tissue was extracted exhaustively at room temperature with acetone and later with methanol–chloroform (3 1 v/v) in order to remove any neuraminic acid-containing gangliosides Part (50 mgm) of the fat-extracted residue was suspended in water and dialysed against 0 01 *N* sulphuric acid at 0° for 2 days The neuraminic acid(s) in the non-dialysable residue was then liberated by heating at 80° for 1 hr with 0 04 *N* sulphuric acid and recovered from the neutralized solution by dialysis The neuraminic acid determination[5] was carried out on this dialysate to avoid interference due to chromogens from other sugars

When the whole of the surgical tissue from each operation was examined in this way the neuraminic acid contents of two carcinomas (0 33 and 0 43 cent) from the pylorus end and one (0 64 per cent) from the cardia end of the stomach were appreciably higher than those (0 11, 0 13 and 0 14 per cent) of three stomach ulcers or those (0 12, 0 16 and 0 18 per cent) of three duodenal ulcers In a more meaningful comparison the tissues obtained from later cancer operations were arbitrarily divided into three portions (*A*) the cancerous or centre of the malignant growth, (*B*) the invasive area in which there is an interlocking growth of the normal and cancer cells, (*C*) the apparently 'normal' area outside The results are given in Table 1

Table 1 NEURAMINIC ACID CONTENT IN VARIOUS AREAS OF A MALIGNANT GROWTH

Type of carcinoma	Percentage neuraminic acid content in area *A*	*B*	*C*
Adenocarcinoma of the colon	0 24	0 26	0 17
Carcinoma of the pylorus and duodenum	0 18	0 18	0 11
Scirrhous carcinoma of the breast	0 29	0 11	0 13
Duct carcinoma of the breast	0 16	0 15	0 08

Bearing in mind the difficulty of deciding on the so-called invasive area and the obvious variation in such an arbitrary division, it is nevertheless evident that the amount of mucoprotein containing neuraminic acid is almost doubled in the area of malignancy

Several types of neuraminic acids (N-acetyl-, N,O-diacetyl-, N-glycolyl-, etc) have now been recognized Paper chromatographic and ionophoretic analysis revealed that the neuraminic acid liberated by hydrolysis of the tissue from two stomach ulcers, a duodenal ulcer, a carcinoma of the pylorus, and from all three areas (*A*, *B*, and *C*) of the colon adenocarcinoma and the scirrhous breast carcinoma was N-acetyl neuraminic acid Both N-acetyl and N,O-diacetyl neuraminic acid were liberated from a malignant tumour situated at the cardia end of the stomach and involving 1 in of the œsophagus

In another aspect of this assessment of the distribution of carbohydrate-containing substances in human tumours we have determined[6] the hexosamine contents of some of the tissues studied above Mucoproteins almost always contain hexosamines, but the hexosamine content of the tissue should not necessarily follow the neuraminic acid values since hexosamines are also components of blood group polysaccharides and many tissue polysaccharides The carcinoma obtained from the cardia end of the stomach which had the highest neuraminic acid content (0 64 per cent) also had the highest hexosamine content (3 3 per cent) of those studied The distribution of hexosamine (1 8 per cent in *A*, 1 6 per cent in *B* and 1 2 per cent in *C*) in the colon adenocarcinoma also followed that of the neuraminic acid content However, the hexosamine content (2 1 and 2 0 per cent) of the whole of the surgical tissue from two stomach ulcers and that (2 3 per cent) of a duodenal ulcer differed little from that (2 2 per cent) of the carcinoma of the pylorus Analysis[7] revealed that glucosamine and galactosamine were the only amino-sugars present in the duodenal ulcer (glucosamine galactosamine, 1 9 1) and in the carcinomas from the pylorus end (glucosamine galactosamine, 2 1 1) and from the cardia end (glucosamine galactosamine, 2 3 1) of the stomach Trypsin digestion[8] of the fat-extracted tissues from the same duodenal ulcer and the two stomach carcinomas, removal of protein with trichloracetic acid and addition of alcohol gave crude polysaccharide mixtures in yields of 2 2, 2 1, and 2 3 per cent espectively Acid hydrolysis of these mixtures iberated hexosamines, fucose, and galactose together vith small amounts of glucose and mannose This uggests that most of the polysaccharide in these issues was of the blood-group substance type The lucose probably originated from the glycogen[9] vhich constituted 0 35 per cent of the duodenal lcer tissue and 0 30 and 0 29 per cent respectively f the stomach carcinomas (all yields calculated on he dried fat-extracted tissue) Ionophoretic analysis f the crude polysaccharide mixtures revealed the resence of small amounts of acidic polysaccharides taining with toluidine blue[10] accompanied by much arger amounts of neutral polysaccharides

We are indebted to the staff of the West Bromwich nd District General Hospital, West Bromwich, taffs, for the provision of tissues We have also ad valuable discussion with Prof J W Orr and r D L Woodhouse of the Cancer Research Laboraories One of us (D J T) thanks the University of irmingham for the award of a scholarship The esearch was supported by a grant from the British mpire Cancer Campaign

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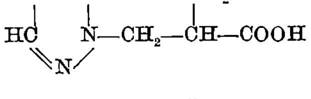
[1] Florey, H , *Proc Roy Soc* , B, **143**, 147 (1955)
[2] Rose, H M , *Fed Proc* , **9**, 390 (1950)
[3] Gottschalk, A , *Biochem J* , **61**, 298 (1955)
[4] Burnet, F M , "Ann Rev Microbiol ", **6**, 229 (1952)
[5] Svennerholm, L , *Arkiv Kemi*, **10**, 577 (1957)
[6] Svennerholm, L , *Acta Soc Med Upsal* , **61**, 287 (1956)
[7] Gardell, S , *Acta chem Scand* , **7**, 207 (1953)
[8] Schiller, S , *Biochim Biophys Acta*, **28**, 413 (1958)
[9] Bell, D J , and Young, F G , *Biochem J* , **28**, 882 (1934)
[10] Ricketts, C R , Walton, K W , and Saddington, S M , *Biochem J* , **58**, 532 (1954)

α-Amino-β-(pyrazolyl-N) Propionic Acid: a New Amino-Acid from *Citrullus vulgaris* (Water Melon)

DURING recent years, several new amino- and mino-acids have been characterized as components f the non-protein nitrogen fraction of plant materials nother example has now been found in seeds of *itrullus vulgaris* (water melon, var Tom Watson) he structure of this new amino-acid (hereafter ermed β*PA*) is as follows



α-Amino-β-(pyrazolyl-N) propionic acid
or β-(pyrazolyl-N) alanine

This amino-acid is unique in that it is the first xample of a natural product which contains a yrazole ring Furthermore, in contrast to the other eterocyclic ring-containing amino-acids, histidine and tryptophan, the side-chain of β*PA* is attached to the pyrazole ring through a carbon to nitrogen bond

The presence of the amino-acid was detected by two-dimensional paper chromatography (water-saturated phenol butanol/acetic acid/water) in a 70 per cent (v/v) ethanol extract of ground seeds It occupied a position very similar to that of proline on two-dimensional chromatograms The compound reacted with ninhydrin to give a normal bluish-purple spot With Ehrlich's reagent (*p*-dimethylaminobenzaldehyde) it gave a yellow-coloured spot, and it formed a copper complex with copper acetylacetonate, so indicating the presence of an α-amino group

By ion exchange chromatography ('Zeokarb 215' and 'Dowex 50'–0 25 *N* ammonia displacement), 3 gm of β*PA* was isolated from 10 lb of water melon seeds. The amino-acid was crystallized twice from distilled water (solubility approximately 4 gm / 100 ml), and yielded a white solid with an elemental analysis of C, 46 7 , H, 5 7 , N, 27 1 , O (by difference), 20 4 The calculated values for β*PA* are C, 46 4 , H, 5 8 , N, 27 0 , O, 20 8

Therefore, the isolated material had an empirical formula of $C_6H_9N_3O_2$, and was isomeric with histidine This formula provides too few hydrogen atoms for the more normal saturated open-chain amino-acid structure The compound was found to be stable to strong mineral acid (6 *N* hydrochloric acid at 100° for 24 hr) and alkali (5 *N* barium hydroxide at 100° for 24 hr) Treatment of the isolate with 55 per cent (w/w) hydriodic acid at 120° for 24 hr degraded it, and alanine was identified as the only ninhydrin-reactive product by comparison with an authentic sample of the amino-acid on paper chromatograms developed in water-saturated phenol, butanol/acetic acid/water mixture, butanol saturated with 2 *N* ammonia, and ethyl acetate/pyridine/water (organic phase of 2 1 2 parts by volume mixture) The fission of an alanine moiety in this way not only indicated its presence in the structure of the isolate but also suggested that the alanine residue was attached to the remainder of the molecule through a C—N linkage (the corresponding C—C linkage found in histidine is stable to hydrogen iodide reduction)

The remaining atoms of the formula are most simply accommodated by assuming the presence of an imidazole or pyrazole ring system It would appear that Shinano and Kaya[1] have isolated a smaller quantity of the same substance from the press-juice of water melon , both isolates had the same elemental analysis and m p (decomp) in the range 236–238° C The Japanese workers suggested that their isolate was α-amino-β-(imidazolyl-N) propionic acid, although no definite proof for the presence of the imidazole residue was given Our evidence provides no support for the idea of an imidazole ring The isolate failed to give the Pauli test, and did not possess a *pK* in the *p*H range 6–7, normally a feature of imidazole derivatives Pyrazole derivatives have an analogous *pK* in the *p*H range 2–3 , the titration curve of the isolate showed a weak point of inflexion in this range Nuclear magnetic resonance spectra[2] performed on the isolate and various N-substituted imidazole and pyrazole derivatives proved almost certainly that the isolate contained the pyrazole ring system The fine structure of the spectrum of the isolate also indicated an unsubstituted α-amino group in the alanine residue and the presence of a —CH_2— group and an N—C linkage These requirements are all met by the above structure for β*PA*

Crude, small-scale preparations of β*PA* and β-(imidazolyl-N) alanine (β*IA*) have been made The silver salts of pyrazole and imidazole respectively were refluxed in methanol with the methyl ester of β-chloroalanine hydrochloride (prepared by the method of Fischer and Raske[3]) After removal of the methanol and hydrolysis with 6 *N* hydrochloric acid, the reaction mixtures contained three amino-acids Serine and a trace of a compound, probably alanine, accompanied either β*PA* or β*IA* The synthetic β*PA* was inseparable from the isolated material on paper chromatograms, whereas β*IA* was easily resolved from the isolate β*IA* had an R_F very similar to that of histidine in water-saturated phenol, in butanol/acetic acid/water mixture it moved slightly more slowly than histidine The yields obtained in these preparations were low, but it is hoped that a future large-scale preparation of β*PA* may provide sufficient crystalline material for comparisons to be made with the natural substance using other accepted physico-chemical techniques

We wish to thank the Ferry-Morse Seed Co (California) for supplying the seed, Dr I L Finar for advice on the syntheses, and Drs J H Ridd and R F M White for their help with the nuclear magnetic resonance spectra

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[1] Shinano, S , and Kaya, T , *Nippon Nogei-Kagaku Kaishi*, 31, 759 (1957) (taken from *Chem Abst* , 52, 15612a (1958))

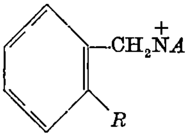
[2] Fowden, L , Noe, F F , Ridd, J H , and White, R F M , *Proc Chem Soc* , 131 (1959)

[3] Fischer, E , and Raske, K , *Ber* , 40, 3719 (1907)

ANIMAL PHYSIOLOGY

New Antiadrenergic Compounds

WE have found that the benzyl quaternary ammonium compounds (I, patents pending) have a novel and highly specific blocking action on the peripheral sympathetic nervous system, which resembles that following section of adrenergic nerves and differs from that produced by adrenolytics, ganglion-blocking agents and reserpine



(I)

Compounds of the above type were screened by examining their efficacy in relaxing the nictitating membrane when injected subcutaneously in the cat Activity was highest in the quaternary compounds (I, *R* = H) and the *ortho*-substituted analogues (I, *R* = *Me*, F, Cl, Br, I, and NO_2) Activity was also very sharply influenced by the cationic head, high activity being encountered in the compounds I with *NA* = NMe_2Et, $NMe_2(CH_2)_2OH$, $EtN(CH_2)_4$, $HO(CH_2)_2N(CH_2)_4$ Lower homologues such as I with *NA* = NMe_3, *R* = Br were inactive and higher homologues showed much reduced activities There was no mydriasis or other overt effect in cats injected with any of these compounds, except one (I, *NA* = NMe_2Et, *R* = H) which caused marked parasympathomimetic effects

One of the most active compounds, 373*C*57 (I *NA* = NMe_2Et, *R* = Br), was examined in detail, as its bromide, and the findings indicating its mode of action are summarized as follows

After subcutaneous injection of 5–10 mgm /kgm of 373*C*57 in the unanæsthetized cat, the nictitating membrane gradually relaxed, becoming fully exposed in 4–6 hr , and retracted only after approximately 24 hr Similarly, in cats under chloralose anæsthesia 373*C*57 gradually inhibited the effect of indirect stimulation of the nictitating membrane irrespective of whether the stimuli were applied to the pre- or post-ganglionic nerve , the block was most marked when the stimulation was continuous This inhibitory effect was accompanied by a gradual and prolonged fall in blood pressure often preceded, when the drug was given intravenously, by a small temporary rise The response of the heart to stimulation of the cardio accelerans nerve was blocked, and the pressor effects of intravenous injections of adrenaline and nor adrenaline were increased

373*C*57 blocked the response to stimulation of the adrenergic nerve in various isolated preparations Thus it prevented the vasoconstriction caused by stimulating the greater auricular nerve in the perfused rabbit ear, the relaxation of the rabbit ileum during stimulation of the visceral efferents, and the contraction of the rabbit uterus elicited through the hypogastric nerve The effects of adrenaline and noradrenaline on these preparations were enhanced after giving 373*C*57

In the cat, the pressor effects of intravenous dimethylphenylpiperazinium iodide and splanchnic nerve stimulation which are mediated by the adrena medulla were greater after giving 373*C*57, whereas the hypertension caused by the ganglion-stimulating action of dimethylphenylpiperazinium iodide in the adrenalectomized animal was blocked This shows that the antiadrenergic action of 373*C*57 is not accompanied by an interference with the adrenal mechanism, such as occurs with the ganglion-blocking drugs or reserpine

Some of the properties of 373*C*57 resemble those of the 2 6-xylylether of choline bromide, *TM*10[1,2] but unlike this compound, 373*C*57 does not cause parasympathomimetic effects or deplete the pressor amine content of the rat adrenal ' The latter finding if it applied also to the adrenergic nerve, would indicate that it is unlikely that 373*C*57 acts either by depleting the local stores of catechol amines or by inhibiting the biogenesis of noradrenaline in adrenergic nerves, as was postulated[3] might be the mode of action of *TM*10 373*C*57 caused no overt behavioural changes in animals, and this together with the absence of depletion of the catechol amine content of the adrenal medulla of rats is in contrast with the actions of reserpine

Together with our colleagues, Drs A McCoubrey and W G Duncombe, we have studied the distribution in tissues of 373*C*57 labelled with carbon-14 in one of its methyl groups Following subcutaneous injection in cats, much higher concentrations of radioactivity were found in adrenergic nerves, sympathetic ganglia and tissues with a rich adrenergic innervation, than in other tissues The concentration of 373*C*57 indicated to be present in adrenergic nerves, when applied topically, blocked the physiological responses to stimulation of the pre- and post-ganglionic cervical sympathetic nerves in the cat, the visceral adrenergic nerves of rabbit intestine, and the greater auricular nerve in the rabbit ear

We conclude that the blocking effect of 373*C*57 on the peripheral sympathetic nervous system is due to an action on adrenergic nerves and that its specificity is related to the selective accumulation of the compound in adrenergic nerves following systemic administration

The properties of 373*C*57 and related antiadrenergic compounds may render them useful for the reduction of sympathetic tone, for example, in the treatment of hypertension, they do not impair parasympathetic functions as do ganglion-blocking agents, nor depress the central nervous system as does reserpine

Note added in proof We have just learned that the open name, approved by the British Pharmacopœa Commission, for 373*C*57 *p*-toluene sulphonate is 'bretylium tosylate'

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[1] Hey, P, and Willey, G L, *Brit J Pharmacol*, 9, 471 (1954)

[2] Coupland, R E, and Exley, K A, *Brit J Pharmacol*, 12, 306 (1957)

[3] Bain, W A, and Fielden, R, *Lancet*, ii, 472 (1957)

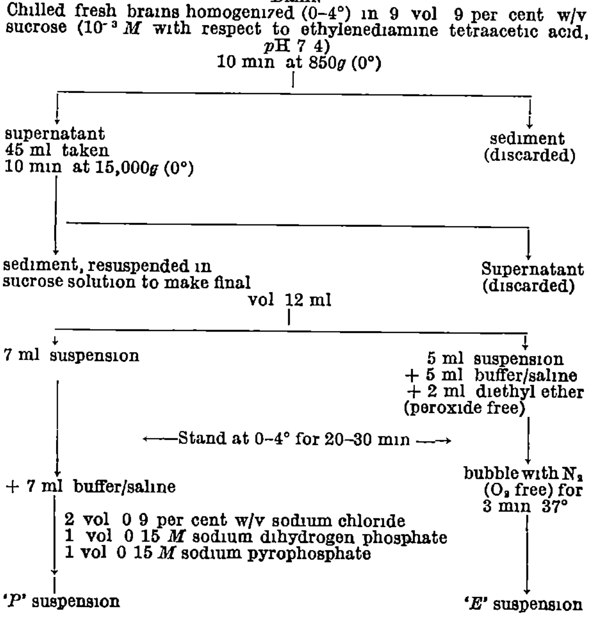
Action of Ganglion Blocking Drugs on Choline Acetylase

THE first practical hypotensive drugs which acted by causing autonomic ganglionic block were *bis*-quaternary ammonium salts, recently, substances containing only a single secondary or tertiary amine group have been introduced as hypotensive agents of a similar type There are, however, differences in the details of the pharmacological actions of the two types of drugs, for example, the mono-amine compounds, mecamylamine and pempidine, are slower in onset of action but more prolonged when compared with the older group (for example, hexamethonium or pentolinium) The *bis*-quaternary ammonium drugs paralyse ganglia by extracellular competition with acetylcholine for synaptic receptor sites, the differences in action might be explicable if the newer compounds acted in some other way, for example, by inhibition of acetylcholine formation Their ability to penetrate cell lipid membranes or barriers makes such an intracellular action plausible

Choline acetylase preparations from guinea pig brain have therefore been used to compare the effects of three of these mono-amine compounds with those of a 'hemicholinium' (*HC*-3), a compound which is known to owe its high toxicity to interference with acetylcholine synthesis[1-2] The enzyme preparations used were modifications of those previously employed and were more dependent on the addition of choline for their activity *HC*-3 inhibits only the weaker '*P*' preparation, this action results from its competition with choline for some limited path of entry into the less damaged particles of that preparation[2]

The three mono-amine compounds tested (mecamylamine, pempidine, and its ethyl analogue, Imperial Chemical Industries Cpd 26539), showed no significant inhibition of either enzyme preparation when tested in the concentration (10^{-4} *M*) at which *HC*-3 reduces the activity of the '*P*' preparation by one half Pempidine was also ineffective at 10^{-3} *M*, a concentration which would be expected to reveal any ability to interfere specifically with the enzyme system

PARTICULATE CHOLINE ACETYLASE PREPARATIONS FROM GUINEA PIG BRAIN


Chilled fresh brains homogenized (0–4°) in 9 vol 9 per cent w/v sucrose (10^{-3} *M* with respect to ethylenediamine tetraacetic acid, *p*H 7 4)
10 min at 850*g* (0°)
supernatant 45 ml taken 10 min at 15,000*g* (0°)
sediment (discarded)
sediment, resuspended in sucrose solution to make final vol 12 ml
Supernatant (discarded)
7 ml suspension
5 ml suspension + 5 ml buffer/saline + 2 ml diethyl ether (peroxide free)
Stand at 0–4° for 20–30 min
+ 7 ml buffer/saline
bubble with N_2 (O_2 free) for 3 min 37°
2 vol 0 9 per cent w/v sodium chloride
1 vol 0 15 *M* sodium dihydrogen phosphate
1 vol 0 15 *M* sodium pyrophosphate
'*P*' suspension
'*E*' suspension

The response of the frog rectus abdominis muscle used to assay acetylcholine was affected by the presence of the drugs, especially by mecamylamine, and it was necessary, to prevent a progressive reduction in sensitivity, to adopt a routine of regular repeated washing and resting of the tissue after each estimation

Contrary to the results reported here, a brief note[3] appeared earlier indicating that mecamylamine can inhibit acetylcholine formation, but recent discussion with the authors has clarified the position. The suggestion arose from preliminary experiments in which a soluble choline acetylase was used, prepared from an acetone powder of rabbit brain, the acetylcholine formed being estimated colorimetrically Mecamylamine was used in amounts equimolar with choline, and since the assay method adopted necessitates a high choline concentration (10^{-2} *M* or more) there was a serious possibility that the inhibition was non-specific Subsequent studies with other secondary amines confirmed this and the work was discontinued

In their investigation of pempidine, Corne and Edge[4] showed that a large dose (10 mgm) could reduce by 40 per cent the acetylcholine output from the cat's perfused superior cervical ganglion in response to pre-ganglionic stimulation Their experi-

Table 1

	'*P*' preparation	'*E*' preparation
Average acetylcholine content n mole/ml suspension	1 7 (1 3–2 5)	0 16 (0 0–0 5)
Average net synthesis of acetylcholine n mole/ml suspension	5 0 (4 0–5 7)	21 4 (19 7–24 7)

Reaction system contained in 2 ml 0 1 μmole acetyl-coenzyme *A* 0 05 μmole choline chloride, 2 μmoles tetraethyl pyrophosphate, 0 2 μmole inhibitor (if any), 50 μmoles sodium dihydrogen phosphate, 50 μmoles sodium pyrophosphate, 1 ml '*P*' or '*E*' enzyme suspension Incubation for 1½ hr at 37° with gentle shaking After incubation reaction stopped by acidification and heating, alkali-treated controls prepared and the acetylcholine content assayed on frog rectus abdominis muscle preparation sensitized with tetraethyl pyrophosphate

Table 2

Compound	Concentration (*M*)	Activity of control (per cent)	
		'*P* preparation	'*E*' preparation
Mecamylamine*	10^{-4}	106, 107, 98	104, 100, 98
Pempidine†	10^{-4}	89, 105, 86	105, 103, 125
Pempidine†	10^{-3}	102	107
26539†	10^{-4}	100, 100	95, 95
HC-3	10^{-4}	47, 80, 40, 57, 50	83, 105, 101, 100, 117

* Used as hydrochloride
† Used as tartrate

ments were of short duration when compared with the time required to show the reduction produced by *HC*-3 on the same preparation[1] The effect seen by Corne and Edge could well be due to a slight local anæsthetic action[5], common among amines

Thus the experiments described here give no support to the hypothesis that the ganglion-blocking agents mecamylamine, pempidine or 26539 act, even in part, by inhibition of acetylcholine formation They affect neither the simple choline acetylase activity of preparation '*E*' nor, in preparation '*P*', the additional limiting step of choline entering the particles

I am grateful to Dr A Spinks, Imperial Chemical Industries, Pharmaceuticals Division, for the pempidine and compound 26539 used in this work

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[1] MacIntosh, F C , Birks, R L , and Sastry, P B , *Nature*, 178, 1181 (1956)

[2] Gardiner, J E , *J Physiol* , 138, 13P (1957)

[3] Crawford, M , quoted by Payne, J P , *Brit J Anaesth* , 29, 358 (1957)

[4] Corne, S J , and Edge, N D , *Brit J Pharmacol* , 13, 339 (1958)

[5] Spinks, A , Young, E H P , Farrington, J A , and Dunlop, D , *Brit J Pharmacol* , 13 501 (1958)

PLANT PHYSIOLOGY

Effect of Gibberellic Acid on the Initiation of Flowers and Runners in the Strawberry

A NUMBER of long-day responses are induced by the application of gibberellic acid to plants growing in short days These include the promotion of stem elongation and flower induction in long-day plants[1] , inhibition of flower initiation in some short-day plants[2] , and delay in the onset of autumn colouring and leaf-fall, and renewal of shoot-growth in woody plants[3] In the strawberry, flowers are initiated under short-day conditions and branch crowns are formed in the axils of the leaf petioles, which are short and prostrate During long days, flowers are seldom initiated, runners are formed in the leaf axils and the petioles are long and upright It has been suggested by one of us[4] that this greater vegetative vigour is the result of the production during long days of a growth-promoting hormone The present experiment demonstrates that gibberellic acid can act as a substitute for this natural product

Gibberellic acid was applied at 100, 50, 25, 12 5 and 0 p p m to plants of Talisman growing in pots in a glasshouse under natural short days from September 4 until November 19 Temperature was not accurately controlled, but the minimum night temperature fell from the range 55–60° F in the earlier part of the experiment to 50–55° F during November Ten plants were used for each treatment and the gibberellic acid solution, with 'Agral' added as a wetter, sprayed on until run off For the first three weeks application was weekly, and afterwards at fortnightly intervals

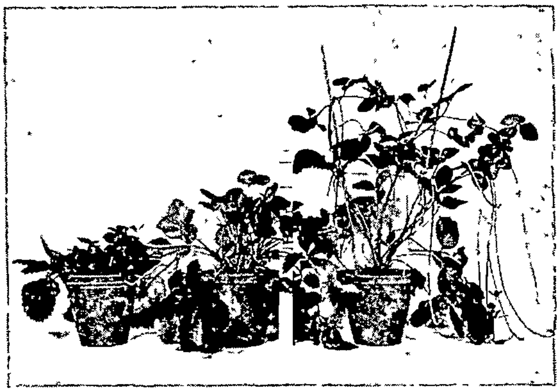

Fig 1 Effect of fortnightly applications of gibberellic acid to strawberries under short days at 25 p p m and 100 p p m Untreated control on the left

The first effects of treatment appeared after about twelve days as a slight paling of the youngest leaves and a very upright growth of the petioles Increase in length of the internodes of the main stems occurred a little later Table 1 shows that the length of the main stem measured over nine internodes from the leaf emerging at the start of treatment was directly proportional to the concentration of gibberellic acid applied In the controls, the increase in length of the main stem over this period was so small that no satisfactory measurement could be made , it was, however considerably less than that found at the 12 5-p p m level Under the conditions of this experiment, length of petiole did not increase with concentration of gibberellic acid to the same degree In all treated plants the petioles were considerably longer than in the controls, but the response at 12 5 p p m was only a little less than that at 100 p p m The difference in response between petioles and stems is illustrated in Fig 1

During November, runners which had failed to emerge were found in the axils of the leaves of some of the treated plants After the removal of two plants from each treatment for dissection, the remainder were reduced to four main stems each and transferred to a lighter and warmer glasshouse, in which the minimum night temperature was in the range 60–65° F , to encourage the emergence of the runners. As a further aid, the tips were removed from two stems on each plant To determine whether the emergence of runners was controlled by length of day in spite of the application of gibberellic acid, half the plants were given a light break from 10 p m until 2 a m using 60-W incandescent lamps suspended 2 ft above the bench, and the other half were given short days with similar illumination during the afternoon from 2 p m until 6 p m

Runners started to emerge immediately under the new conditions, and after twelve days runner emergence was recorded All the runners counted had been initiated in the natural short-day conditions of the first glasshouse The number of runners emerging was not affected either by photoperiod or by tipping, and their failure to emerge earlier must have been the result of poor growing conditions In Table 1 these secondary treatments have been combined and production of runners is shown as the mean number of runners produced per crown at each level of application The appearance of the plants three weeks after transfer to the warmer glasshouse is shown in Fig 1

Table 1

Gibberellic acid (p p m)	Inflorescences per crown	Runners per crown	Mean length of main stems (mm)
None	1 00	0 00	—
12 5	0 58	0 25	14
25	0 25	1 16	41
50	0 00	1 22	115
100	0 00	1 59	289

Records for flower initiation were obtained, first from the plants dissected at the time of transfer to the second glasshouse, and second by counting inflorescences emerging after transfer to this house All the inflorescences counted had been initiated during the course of the natural short-day treatment, these are shown in Table 1 as the mean number of inflorescences per crown at each treatment-level

All these results, namely, increase in length and upright growth of the petioles, initiation of runners instead of branch crowns, and suppression of flower initiation, are typical of the response of this plant to long-day conditions It would seem that gibberellic acid can serve as a substitute for a growth-promoting hormone produced naturally under long-day conditions On the other hand, the fact that complete suppression of flower initiation and the highest level of runner production was not reached until the concentration of gibberellic acid was such that it caused abnormal elongation of the main stems would suggest that the long-day growth-promoting hormone and gibberellic acid are not identical, although they may be closely related

The gibberellic acid solution used in this experiment was kindly supplied by Plant Protection, Ltd

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[1] Wittwer, S H , and Bukovac, M J , *Quart Bull Mich Agric Exp Sta* , 39, 661 (1957)
[2] Harder, R , and Bunsow, R , *Planta*, 51, 201 (1958)
[3] Brian, P W , Petty, J H P , and Richmond, P T , *Nature*, 183, 58 (1959)
[4] Guttridge, C G , *Ann Bot* , N S , 23, 351 (1959)

Effect of Indole Acetic Acid and α-Naphthalene Acetic Acid on the Growth, Flowering and Fruit Set in Sweet Potato

Sweet potato (*Impomoea batatas* (L) Lam) is cultivated for its tuber and its foliage, which is used as cattle food It is usually propagated either by the tuber slips or stem cuttings, in India the latter method is usually followed Hernandez *et al*[1] reported that the tubers when dipped momentarily in 2,4-D at 10 p p m produced a significantly larger number of plants than the control, but they did not study the effect of the chemical on stem cuttings or on tuber yield. Howell and Wittwer[2,3] observed that 2,4-D sprays induced better flowering in sweet potato Mikell[4] found that 2,3,5-triiodobenzoic acid, 2,4-D and α-naphthalene acetic acid failed to induce any flowering when the plants were treated either by the wick method, foliage spray or soil application

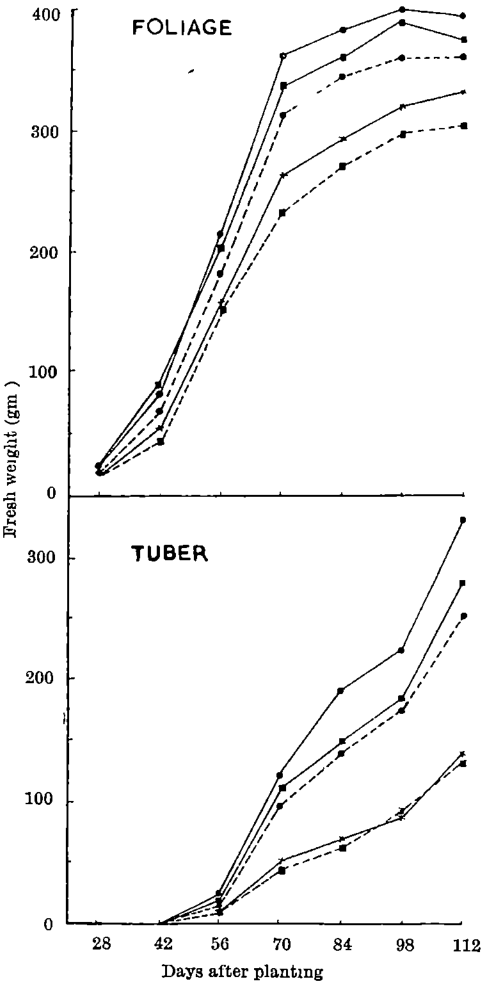

Fig 1 The influence of indole acetic acid and naphthalene acetic acid on the growth of foliage and development of tubers in sweet potato, as indicated by their fresh weight Indole acetic acid ●—●, 25 p p m , ●---●, 10 p p m Naphthalene acetic acid ■—■, 1 p p m , ■---■, 25 p p m ×—×, control

Studies were undertaken by us recently to find out the effect of two plant-growth regulators, namely, naphthalene acetic acid and indole acetic acid, on the growth, tuberization, flowering and fruit set in sweet potato Stem cuttings of uniform thickness and 12 in in length were selected from a local white variety of sweet potato The basal ends were immersed up to one inch in various concentrations of the growth regulators in water and in water alone as control When the cuttings were immersed for 24 hr in water, root development was inhibited, this did not occur after 12 hr immersion Subsequent studies were therefore made by treating the stem cuttings for 12 hr only The treated cuttings were washed thoroughly with tap water and planted in a well-prepared field on ridges with a spacing of 24 in × 12 in , 60 cuttings were planted from each treatment The plants were maintained with periodic irrigation and weeding, following the local practice

Observations on the growth of foliage, tuberization, flowering and fruit set were made at intervals. Three plants were selected at random from each treatment and the growth of shoot and root measured, the amount of tuberization was recorded by carefully digging out the plants, washing the tubers free from soil and taking the fresh weight Representative samples of the foliage and tubers were collected and the dry weight and moisture percentage estimated The rates of growth of foliage and roots in terms of their average fresh weights are shown in Fig 1 All the treatments, except α-naphthalene acetic acid 25 p p m, were found to cause better growth of foliage and tuberization, as compared to the controls Among the treatments, indole acetic acid 25 p p m gave the best results In general the chemical treatments hastened the growth of foliage, except in the case of 25 p p m naphthalene acetic acid, where there was a definite reduction in the weight (Fig 1) The treatments produced no significant difference in the moisture content of foliage or tubers The tubers in plants treated with indole acetic acid were characterized by linear developments, whereas with naphthalene acetic acid no such effect was observed

All the treated plants flowered earlier and comparatively more than in the controls There was also more fruit set in all the treated plants, indole acetic acid at 10 p p m giving the best results (Table 1) The seeds on maturity were collected separately and on testing were found to germinate 100 per cent, giving rise to normal plants

Table 1 THE EFFECT OF INDOLE ACETIC ACID (IAA) AND NAPHTHALENE ACETIC ACID (NAA) TREATMENTS ON THE FLOWERING AND FRUIT SET IN SWEET POTATO

Treatment (p p m)		First flowering after (days)	Average No of flowers per plant	Average fruit set per plant	Fruit set (per cent)
Control	0	79	80	*	—
IAA	1	55	136	24	17 6
	10	50	180	38	21 1
	25	57	115	19	16 5
NAA	1	71	96	16	16 6
	10	64	121	14	11 6
	25	65	111	10	9 0

* Occasionally one or two fruits were found set in a few plants, which might be due to open pollination

Seed setting in sweet potato seems to be rare under natural conditions[5,6] The results obtained in the present work indicate the possibility of increasing the foliage and tuber yields as well as increasing the flowering and fruit set by treating the stem cuttings with plant-growth regulators before planting Further studies are in progress

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[1] Hernandez, T P, Miller, J C, and Fountenot, J F, *Proc Amer Soc Hort Sci*, **55**, 423 (1950)

[2] Howell, M J, and Wittwer, S H, *Science*, **120**, 717 (1954)

[3] Howell, M J, and Wittwer, S H, *Proc Amer Soc Hort Sci*, **66**, 279 (1955)

[4] Mikell, J J, *Proc Amer Soc Hort Sci*, **60**, 295 (1952)

[5] Montelaro, J, and Miller, J C, *Proc Amer Soc Hort Sci*, **57**, 329 (1951)

[6] Richharia, R. H, and Ghosh, A N, *Ind J Hort*, **6**, 33 (1954)

ANIMAL PATHOLOGY

Effect of Proflavine on the Formation of the Virus of Foot-and-Mouth Disease and its Infective Ribonucleic Acid in Pig Kidney Tissue Culture Monolayers

PROFLAVINE inhibits the growth of bacterial viruses by blocking some process or processes connected with the formation of the infective virus particle from its sub-units Antigens, specific to the virus, are still synthesized in the presence of proflavine although fully infective virus particles are not produced These observations have also been made with some animal viruses (vaccinia[1,2], fowl plague[3], poliomyelitis[4]) The action of proflavine is regarded as being due to the inhibition of cytoplasmic protein synthesis, but Dulbecco and Vogt[5] have shown that low concentrations of proflavine induce mutations in the virus of poliomyelitis, so the compound probably has some action on the nucleic acid of this virus

As it has recently been shown[6] that infective ribonucleic acid can be obtained from pig kidney tissue culture cells infected with the virus of foot-and-mouth disease before fully infective virus is formed, it was considered that it would be of interest to study the effect of proflavine on the synthesis of infective virus and its ribonucleic acid in this cell system Pig kidney cells grown in monolayers were infected with strain 997 (type *C*) of the virus (10^6 *ID*50 on each monolayer of 2×10^6 cells) After 30 min adsorption the sheets were washed, medium containing 0–6 μgm proflavine per ml added and the cultures incubated at 37° C for 4 hr The entire cultures were then either (*a*) treated with 0 1 per cent sodium dodecyl sulphate[7] to disrupt the cells and the released virus titrated in 7-day unweaned mice, or (*b*) treated with phenol[8] at 2° C and the infective ribonucleic acid titrated in pig kidney cell monolayers In view of the photodynamic action of proflavine on the virus of foot-and-mouth disease[9], all the experiments were carried out in the absence of light or in subdued lighting conditions The results in Table 1 show that a marked inhibition of infective virus synthesis occurred when the medium above the infected monolayer contained proflavine As little as 1 μgm proflavine per ml reduced the infective virus titre thirty-fold, whereas the infective ribonucleic acid titre was unaffected by this concentration When the proflavine concentration was increased to 2 μgm /ml the virus titre was reduced by a factor of one thousand but the ribonucleic acid titre was reduced only ten-fold It is clear, therefore, that proflavine exerts a much greater effect on the formation of fully infective virus than it does on the synthesis of the infective ribonucleic acid

Infected monolayers incubated in the presence of 2 μgm proflavine per ml showed cytopathogenic

Table 1 EFFECT OF PROFLAVINE ON THE SYNTHESIS OF VIRUS AND INFECTIVE RIBONUCLEIC ACID BY PIG KIDNEY CELLS INFECTED WITH FOOT-AND-MOUTH DISEASE VIRUS

Proflavine (μgm /ml)	Virus titre (log *ID*50/ml)	Infective ribonucleic acid (log *ID*50/ml)
0	6 8	2 7
0 5	6 3	—
1 0	5 3	2 6
1 5	4 4	1 7
2 0	3 8	1 5
3 0	3 8	0 4
4 0	3 3	Non-infective
6 0	2 8	Non-infective

changes similar to those seen in duplicate virus-infected cultures incubated in the absence of proflavine. Although these changes occurred more rapidly in the monolayers free from proflavine, with medium containing 2 µgm./ml. the cells were beginning to show cytopathogenic changes after 4 hr. and were completely off the glass after 24 hr. When the concentration of proflavine was increased to 10 µgm./ml., however, no change was apparent in 4 hr. although the cells had rounded and partly left the glass after 24 hr. Cell sheets which had not been infected with virus were unaffected by medium containing 10 µgm./ml. in 24 hr.

The action of proflavine in inhibiting the synthesis of infective virus is very rapid. The results in Table 2 show the effect of adding 2 µgm. proflavine per ml. to virus-infected monolayer cultures at various intervals after infection and then continuing the incubation so that each culture was incubated for a total of 4 hr. following infection. Virus synthesis was stopped almost immediately, as shown by the corresponding titres in columns 2 and 3 of Table 2.

Table 2. EFFECT OF PROFLAVINE ON THE PRODUCTION OF INFECTIVE VIRUS IN PIG KIDNEY CELL MONOLAYERS

Time after infection (hr.)	Virus titre at time of adding proflavine (log *ID*50/ml.)	Virus titre at 4 hr. (log *ID*50/ml.)
0·5	2·5	2·5
1·0	2·3	3·0
1·25	2·3	3·0
1·5	3·0	3·3
1·75	3·8	4·5
2·0	4·3	4·5
3·0	6·3	6·0

Although the culture fluids obtained 24 hr. following infection of pig kidney cell monolayers with virus fixed complement with the type-specific antiserum, the culture fluids obtained from similarly infected monolayers which had been incubated in the presence of 2 µgm. proflavine per ml. did not fix complement. This effect of proflavine must be on the virus-cell system, as the complement-fixing activity of virus suspensions was unaffected by treatment with the same concentration of proflavine. These experiments lead to the conclusion that at low concentrations proflavine can exert a differential inhibiting effect on the formation of viral protein, with the result that infective ribonucleic acid is still formed whereas the synthesis of infective virus is greatly inhibited.

We wish to thank Dr. I. A. Galloway for bringing to our notice the photodynamic action of proflavine on the virus and Mr. B. Cartwright for carrying out the complement-fixation tests.

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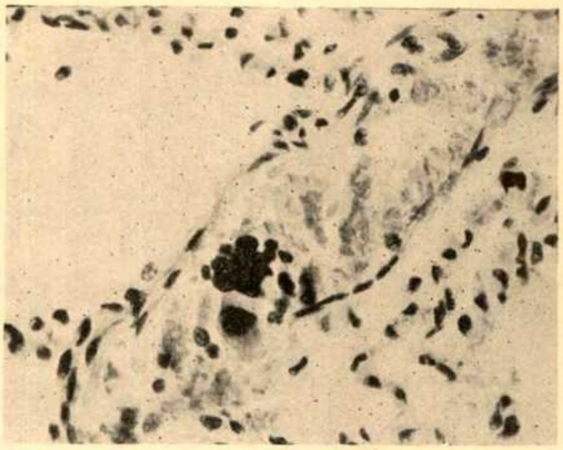
Thompson, R. L., *J. Immunol.*, **55**, 345 (1947).
Briody, B. A., and Stannard, C., *J. Immunol.*, **67**, 423 (1951).
Franklin, R. M., *Virology*, **6**, 525 (1958).
Ledinko, N., *Virology*, **6**, 512 (1958).
Dulbecco, R., and Vogt, M., *Virology*, **5**, 236 (1958).
Brown, F., and Stewart, D. L., *Virology*, **7**, 408 (1959).
Cartwright, Sheila F., and Thorne, H. V., *J. Gen. Microbiol.*, **20**, 61 (1959).
Gierer, A., and Schramm, G., *Nature*, **177**, 702 (1956).
Galloway, I. A., Fifth Progress Report Foot-and-Mouth Disease Research Committee, Appendix III, p. 342 (H.M. Stationery Office, London, 1937).

A Possible Explanation of the Formation of Long Platelets from Pulmonary Megakaryocytes

THE purpose of this communication is to suggest a possible explanation of the formation of the elongated sausage-shaped, sometimes bizarre long platelets that are occasionally encountered in human blood smears. Since Bizzozero[1] first described the platelets as a distinct entity in 1882, much has been conjectured as to the source and mechanism of their formation. Before Wright[2] described the formation of blood platelets from bone marrow megakaryocytes in the marrow sinusoids in 1910, the thrombocytes were assumed to be formed from disintegration of erythrocytes and leucocytes. Howell and Donahue[3] unsuccessfully attempted to show by lung perfusion studies in 1937 that the thrombocytes were formed from megakaryocytes. The latter they believed originated in the lungs. More recently, Humphrey[4] has added chemical evidence to the hitherto purely morphological evidence that the platelets are derived from the megakaryocytes. But according to Wintrobe[5]: "The mechanism of production of platelets from the cytoplasm of megakaryocytes is by no means clear."

Unaware of the studies of Howell and Donahue, Sharnoff and Kim[6] recorded their observations on pulmonary megakaryocytes which appeared to



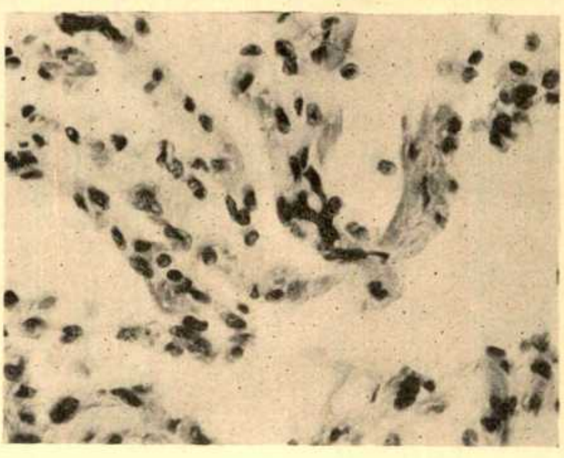
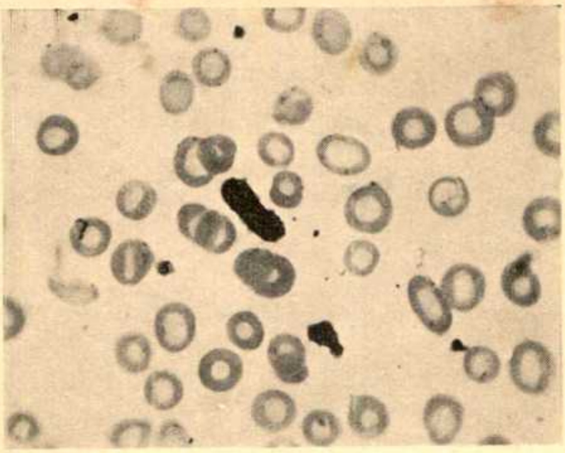


Fig. 1 (above). Megakaryocytes in human pulmonary pre-capillary blood vessel (× 414). Fig. 2 (below). Megakaryocyte dividing in the capillary anastomoses of the human lung. (× 414)

(*Photograph: Robert T. Duckworth*)



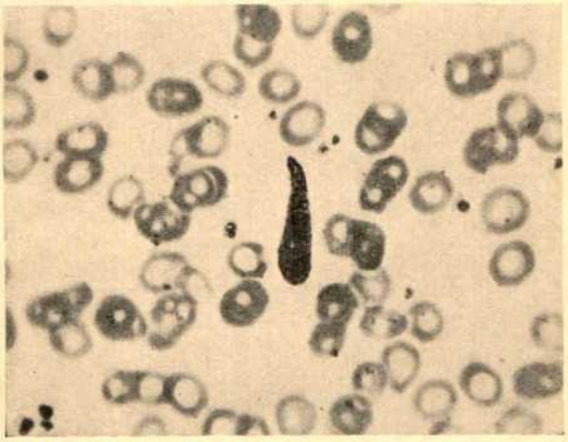


Fig. 3 (above). Sausage-shaped long human blood platelet (×830, oil immersion). Fig. 4 (below). Long human blood platelet (× 830, oil immersion)
(*Photograph : Robert T. Duckworth*)

indicate that the presence of these cells in mammalian lung vessels is a normal phenomenon, where they appear to break up into platelets. Their studies demonstrated that the cells seen in the lung vessels were identical histochemically and morphologically with the bone marrow megakaryocytes and that they were transported from the bone marrow to the lungs by the venous circulation. Their histological observations indicated that the megakaryocytes are too large to pass the lung capillaries intact (Fig. 1) and that the cells appeared to break up in the capillary anastomoses by the pumping action of the right heart ventricle (Fig. 2). The megakaryocytes appeared to be moulded into the shape of the capillaries and divided by their anastomoses. It was postulated that in assuming the capillary outline by being pressed into the vessels the cells can emerge as casts of the vessels, thus occasionally being encountered in blood smears as long platelets (Figs. 3 and 4). It can be further postulated that further break up of these elongated platelets may occur in the eventual passage through the peripheral capillary vascular system. It also would appear that the elongated forms are more commonly seen in individuals with high platelet counts where the platelets appeared freshly formed.

In summing up, it would appear that long platelets may be formed from pulmonary megakaryocytes by being pressed into the lung capillary blood vessels and emerge as casts of the same.

This work was supported in part by a grant form the Westchester Heart Association.

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[1] Bizzozero, J., *Virchows Arch. Path. Anat.*, **90**, 261 (1882).
[2] Wright, J. H., *J. Morphol.*, **21**, 263 (1910).
[3] Howell, W. H., and Donahue, D. D., *J. Exp. Med.*, **65**, 169 (1937).
[4] Humphrey, J. H., *Nature*, **176**, 38 (1955).
[5] Wintrobe, M. M., "Clinical Hematology", fourth edit., 263 (Lea and Febiger, Philadelphia, 1956).
[6] Sharnoff, J. G., and Kim, E. S., *Amer. Med. Assoc. Arch. Path.*, **66**, 176 (1958).

A Seasonal Rhythm in the Presentation of Bone Sarcoma in Man

FROM a study of the ætiology of osteogenic sarcoma in man carried out during the past four years, it has been possible to demonstrate certain trends in the age and sex incidence of these relatively rare neoplasms[1,2]. Probably the most interesting features are the observations that the tumours tend to arise at an earlier age in females among adolescents, and also the higher incidence of tumours of the arm and pectoral girdle at an earlier age compared with those of the leg and pelvis in juveniles of both sexes. On comparison of the mean ages of groups of osteogenic sarcomata in adolescent males and females, whether for the whole skeleton or for individual bones, the differences of mean ages (male minus female) are seldom statistically significant, nevertheless they are almost invariably in the same direction.

The most likely explanation of these differences in age, sex and site would seem to lie in the relatively advanced skeletal growth of girls, and in the general cephalad-caudad sequence of growth progression. It is well known of course that the majority of osteogenic sarcomata of adolescents arise in the metaphyses of the major long bones, although this feature of consistent anatomical location is not so clearly defined in tumours of persons over the age of fifty-five years, among whom Paget's osteitis deformans forms the background of the majority of cases—at least in Great Britain[1]. In this older age-group the trends mentioned above cannot be shown to occur.

Among the characteristic patterns of juvenile bone growth is a seasonal rhythm with the maximum velocity peak in the spring months of April, May and June. The literature on this subject has been discussed by Brody[3] and by Tanner[4], the former author comparing the human growth-cycle with other photoperiodic phenomena of mammals and birds. In discussing this topic Tanner[4] states that the monthly height-gain average for the period April–June may be as much as 2–2½ times that of the months October–December.

In the light of these considerations an analysis was made of the case-histories of 102 osteogenic sarcomata included in the records of the Bristol Bone Tumour Register ; and from among these were eventually separated a group of 40 tumours of long bones all in persons less than 30 years old. This small series was supplemented by the addition of a further 34 cases from four other hospitals, details being furnished by the consultant surgical staffs and medical records officers of these institutions. These 74 cases have been plotted in Fig. 1 according to the month when they first complained of any definite symptom directly related to their subsequent clinically apparent tumour. This initial symptom was most often bone pain—less frequently pain and local swelling. The data are cumulative over a period of 18 years (1941–58). It will be noted that the incidence of tumours is greater during the months June–November inclusive, when the monthly average was 9·2 tumours per month, than for the months December–May, when the average of 3·2 tumours per month was encountered. (This difference is statistically significant: $\chi^2 = 16{\cdot}33$; $P < 0{\cdot}01$.)

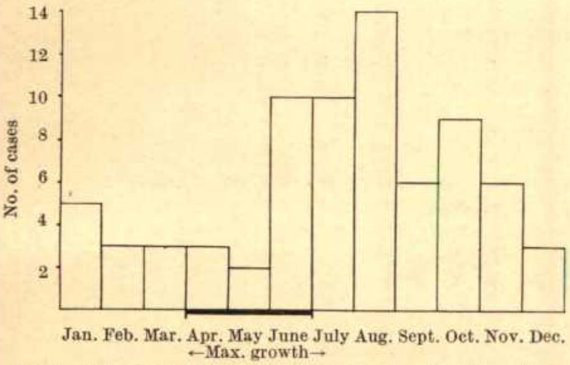

Fig. 1. Osteogenic sarcoma—long bone cases only, all less than 30 yr. old. Plotted according to month of presenting symptom: 'summer' period (June–November, inclusive), 55 cases; 'winter' period (May–December, inclusive), 19 cases; total, 74 cases

The same data were re-examined by annual groups (1943–58), but excluding 4 tumours which were recorded for the years 1941–42. Although the numbers each year are small, the trend of numerical preponderance in 'summer' still appears. The annual distributions are shown in Fig. 2. In 13 of 16 recorded years the number of tumours presenting during the 'summer' period is greater than that encountered for the corresponding 'winter' period. (These differences are again significant, $t = 3{\cdot}04$; $P < 0{\cdot}01$.)

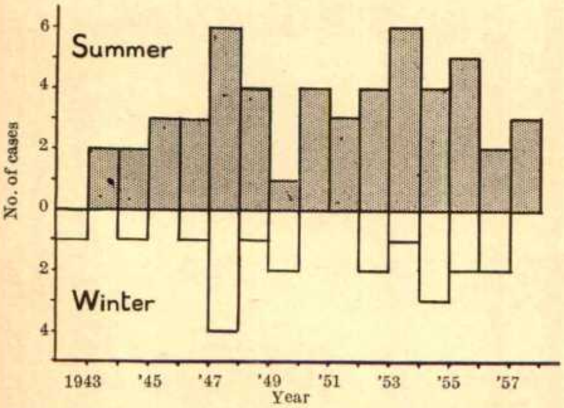

Fig. 2. Osteogenic sarcoma—same series as Fig. 1, plotted by years according to timing of presenting symptom. Comparing numbersin 'summer' and 'winter' periods the difference is statistically significant ($P < 0{\cdot}01$)

For brevity's sake it may simply be stated here that these differences in monthly incidence do not appear in a similar analysis of a series of 55 osteogenic arcomata in older persons more than thirty years of age. This negative result might be expected in view of the modified ætiology of bone tumours of this age-group.

It may be added that this increase in 'summer' incidence in the presentation of sarcomata holds for either sex when the whole series is so sub-divided. Moreover, it exists in each of the four major component groups of cases which were derived from Bristol, London, Manchester and Glasgow. (It has also appeared in a further group of 15 patients, details of whom were received too late for inclusion in the present study.)

With the material available it is not yet possible to define the shape of the 'summer' peak or its precise timing; but in all probability it appears sometime during July and August, that is, about 3 months after the spring peak in the bone-growth velocity curve.

In adolescents the growth of bone in length with subsequent remodelling continues throughout the year, and is responsible in some obscure way for the basic monthly level of incidence of bone sarcoma. The probable size of the lag period between the two peaks of spring growth and presentation of bone sarcoma would seem however to suggest a biological linkage, especially in the light of collateral evidence which relates these two phenomena. Inquiry has not indicated any extraneous factors which might otherwise account for this abnormal distribution of tumour presentation during the yearly cycle.

Dr. Grace M. Jeffree has assisted in this work by examining the case records of the Bristol group, and Mr. G. M. Clarke has given invaluable advice with the statistical treatment of the material.

Details of patients have been freely given by the contributing members of the Bristol Bone Tumour Registry: by Mr. H. Jackson Burrows, and the Medical Records Officer and Committee of the Royal National Orthopaedic Hospital, London: by Dr. Ralston Patterson, of the Christie Hospital and Holt Radium Institute, Manchester: by Mr. Rowland Barnes, and Dr. Mary Catto, of the Glasgow Western Infirmary: and by Dr. Constance A. P. Wood, of the Hammersmith Hospital, London.

This investigation was supported by grants from the British Empire Cancer Campaign.

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[1] Price, C. H. G., *Brit. J. Cancer*, **9**, 558 (1955).
[2] Price, C. H. G., *J. Bone and Joint Surg.*, **40**,B, 574 (1958).
[3] Brody, S., "Bioenergetics and Growth" (Reinhold Pub. Corp., New York, 1945).
[4] Tanner, J. M., "Growth at Adolescence" (Blackwell Scientific Pub., Oxford, 1955).

PLANT PATHOLOGY

Needle Transmission of a New Maize Virus

The rough dwarf disease of maize ("Nanismo Ruvido del Mais") has been known from Italy since 1949[1] and has lately been reported from Israel too[2]. The symptoms of the disease and its epidemiology were described in both countries[3,4] with the assumption that the causal agent is a plant virus. Since no experimental transmission of the disease had been accomplished, it was not certain that the agent was a virus. All attempts to transmit the disease by rubbing sap into maize leaf blades, using various abrasives, have failed. Transmission trials with a local dodder species, *Cuscuta eigii* Sroëlov, also proved negative.

Recently, however, transmission has been achieved for the first time by the following method. Hybrid maize plants showing severe dwarf symptoms were ground in a meat mincer, the sap squeezed through a cheese cloth and then centrifuged for 5 min. at 3,000 r.p.m. The supernatant fluid was injected by means of a 1 c.c. tuberculin syringe into the stalks of 3-week-old hybrid maize seedlings (Neve Yaar hybrid 22, single cross) grown under insect-proof conditions. The dosage was about 0·2 c.c. per seedling divided into 5 punctures at different sites. A control series was injected with healthy sap in the same manner. Three out of twelve plants injected with diseased sap, in two different series, developed both stem and leaf symptoms (including the rare symptom of split blade) within two months. As this was done in winter, without artificial illumination, it is believed that during summer the development of symptoms should be faster. Infectivity of the sap, when frozen, was retained for at least 24 hr. Since the virus is not transmitted by seed, the reliability of the test seedlings is unquestionable.

Similar cases where mechanical transmission of plant viruses could be obtained by needle inoculation only are those of sugar beet curly top[5] and clover wound tumour[6]. Both these viruses are leaf hopper-borne and, at least in the case of curly top, the virus is believed to exist in the phloem which might be considered inaccessible to ordinary surface rubbing[7]. In the case of the maize rough dwarf virus it may be inferred from Biraghi's studies[8] on the pathological anatomy of the disease that the virus tends to inhabit the phloem, though its natural vector is still unknown.

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[1] Fenaroli, L., *Notiz. malatt. piante*, **3**, 38 (1949).
[2] Harpaz, I., Minz, G., and Nitzani, F., *FAO Plant Prot. Bull.*, **7**, 43 (1958).
[3] Grancini, P., *Maydica*, **3**, 67 (1958).
[4] Harpaz, I., *Hassadeh, Tel Aviv*, **39**, 607 (1959) (in Hebrew).
[5] Severin, H. H. P., *Phytopath.*, **14**, 80 (1924).
[6] Brakke, M. K., Valler, A. E., and Black, L. M., Brookhaven Symp. Biol., No. 6, 137 (1954).
[7] Bennett, C. W., *Bot. Revs.*, **6**, 427 (1940).
[8] Biraghi, A., *Ann. Sper. Agric.* (N.S.), **6**, 1043 (1952).

BIOLOGY

Black Marlin in British East African Waters

RECENTLY I stated that only the striped marlin (*M. audax*) had been caught by the East African Marine Fisheries Research Organization, and records of the black marlin in these waters were of doubtful value[1].

Since that communication I have taken two black marlin while using a longline 10 miles off the Tanganyika coast at latitude 8° S.; the fish were of standard length 2,130 and 2,325 mm. and weight 125 and 135 lb. respectively. On capture and comparison the differences from the striped marlin were most obvious—a very low dorsal fin, deep body, steeper head profile and 'rigid' pectoral fins. Proportional measurements confirmed the field observations and an examination of the morphology of the pectoral girdle showed it to be similar to that described by Morrow[2] as diagnostic for the black marlin. Colour was as follows: in life, upper two-thirds of body and fins blue-grey and lower third of body white, the join between the two colours being distinct; on death, the colour fades rapidly and the body and fins become grey, a little darker above. There are at no time any signs of the vertical stripes or brilliant cobalt blue coloration of the striped marlin.

Morrow (personal communication) reveals that his Pemba specimen of marlin weighed 159 lb. at 2,151 mm. and *not* 259 lb., as reported in his paper on East African fishes[3], and thus the record is validated as that of a black marlin.

In a recent paper on marlin taxonomy, Morrow[4] examined the pectoral girdle of the remains of Playfair's type specimen of *H. brevirostris* from Zanzibar and found it to correspond exactly to that of the black marlin[2]. Thus the position of this fish is clarified, the original proportional measurements and later examinations of the type specimen being insufficient for exact identification as stated earlier[1].

The black marlin is rare in this area, only two having been caught hitherto by this Organization, as compared with eighty-four striped marlin.

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[1] Williams, F., *Nature*, **183**, 762 (1959).
[2] Morrow, J. E., *Bull. Bingham Oceanogr. Coll.*, **16** (2), 88 (1957).
[3] Morrow, J. E., *Ann. Mag. Nat. Hist.*, **7** (12), 819 (1954).
[4] Morrow, J. E., *Bull. Mar. Sci. Gulf and Caribbean*, **8** (4), 359 (1958).

A Chimæric Duck with the Head of a Chick

IT is well known that the chick embryo fails to produce detectable antibodies against various foreign antigens, so providing a favourable environment for culturing viruses and transplanting various tissues of

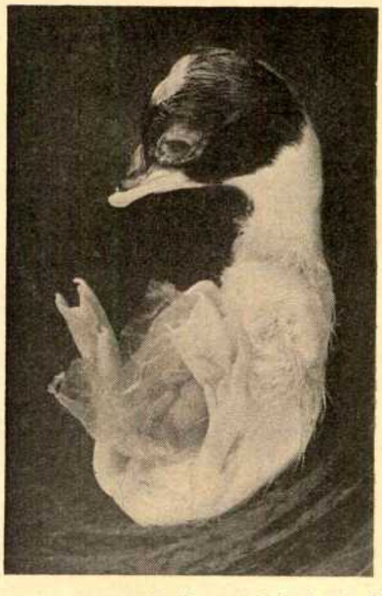

Fig. 1. A duck embryo with the grafted head of a chick, after 28 days of incubation

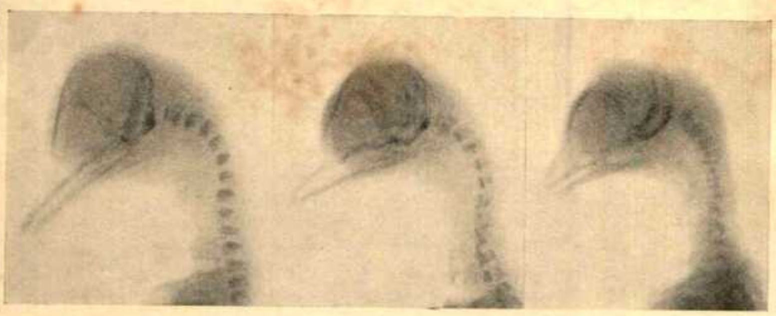

Fig. 2. X-ray photographs of the skulls at hatching. Left, a duck; centre, the chimæra (Fig. 1); right, a chick. Note the striking similarity between the duck and the chimæra, except the upper beaks

birds and mammals[1]. It is also known from the work of Billingham *et al.*[2] that "actively acquired tolerance", the power to react immunologically against foreign homologous tissue cells with which they have been inoculated in fœtal life, is never developed by birds and mammals, or developed only to a limited degree. A renewed interest in heterotransplantation stimulated us to graft various types of tissue primordia between embryos of two different genera of birds, the chick (Galliformes) and the duck (Anseres). Using the same combination, Hašek and his co-workers were not successful in inducing a tolerance for skin heterografts between young obtained by embryonic parabiosis[3] or between young injected with each other's spleen or bone marrow cells shortly after hatching[4]. On the other hand, some cases of limb bud grafting during early days of incubation by Eastlick[5] seem to indicate a certain degree of tolerance, although his experiment was carried out from a point of view of tissue incompatibility in heterologous combination[6].

As one of an experimental series of reciprocal chick–duck heterotransplantation, the grafting of the forebrain region following the technique originally developed by Martinovitch on the chick embryos[7] was performed. The heads were severed just behind the optic vesicle, and were exchanged between the embryos of white duck and a coloured breed of chick, Barred Plymouth Rock, at stages corresponding to Hamburger and Hamilton's stage 10–11. These stages were reached by the chick after about 42 hr., and by the duck after about 55 hr. of incubation at 37·5° C. While the chick embryos grafted with duck heads did not survive for long, one of the duck embryos with the head of a chick survived through the whole length of its embryonic life, 28 days of incubation (26 days after grafting). Fig. 1 illustrates this chimæric embryo.

In size and in growth of feathers, the chimæra resembles the average duck embryo at hatching. However, the umbilical ring was still large and the withdrawal of the yolk into the body cavity had not begun. The host duck was found by examining the gonad to be a male. The contribution made by the graft was represented by the upper beak and eyes, the under-developed crest and the melanophores. The latter spread over both lateral surfaces of the head far caudad beyond the auditory opening, leaving unpigmented only the feathers on a mesial portion in the occipital region. It was clear that an extensive migration of the chick melanoblasts had taken place because the ear region is obviously of duck origin. At the top of the head, there was a round area where no feathers and melanophores were present. The cause of this is not clear. When an X-ray photograph of the skull of the chimæric embryo was compared with those of normal duck and chick embryos at hatching (Fig. 2), it proved to resemble the former much more than the latter. This indicates that skull of the chimæra was derived mainly from duck head mesenchyme.

While this grafting was being undertaken, Martinovitch published the results of grafting by the same method and combination[8] in which considerable abnormalities were reported. Our efforts to hatch these chimæras have been unsuccessful, and the prospect is rather dubious (Martinovitch, P. N., personal communication). However, a greater possibility of survival could be expected in the combinations of genetically more closely related species.

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[1] Tyler, A., in "Analysis of Development", edit. by Willier, B. H., Weiss, P., and Hamburger, V., 556 (Saunders, Philadelphia, 1955).

[2] Billingham, R., Brent, L., and Medawar, P. B., *Nature*, **172**, 603 (1953).

[3] Hašek, M., *Ceskoslovenská Biologie*, **3**, 327 (1954).

[4] Hasková,, V., and Hašek, M., *Folia Biologica* (Prague), **3**, 49 (1957).

[5] Eastlick, H. L., *Physiol. Zool.*, **14**, 136 (1941).

[6] Billingham, R., Brent, L., and Medawar, P. B., *Phil. Trans. Roy. Soc.*, B, **239**, 357 (1956).

[7] Martinovitch, P. N., *Proc. U.S. Nat. Acad. Sci.*, **43**, 354 (1957).

[8] Martinovitch, P. N., *Nature*, **182**, 572 (1958).

The Benthos of Soft Sea-bottom in Arctic North America

QUANTITATIVE surveys of the benthos of soft sea-bottom were made in Baffin Island, N.W.T., during 1954 and 1955, in Greenland during 1956, and in Foxe Basin, N.W.T., during 1957, as part of expeditions organized by the Arctic Institute of North America and the Fisheries Research Board of Canada. These surveys, and others made previously in Greenland, show that *Macoma calcarea* communities[1] with standing crops generally greater than 200 gm./m.[2] (fresh weight) occur in shallow water to about 50 m. depth in many localities in arctic North America. Other communities, some with very small crops, also occur in shallow water under localized, special conditions. They are the *Venus fluctuosa*, *Portlandia arctica* and *Chiridothea sabini* communities. The soft-bottom benthos in water deeper than about 50 m. forms at least two communities, the Foraminifera and *Arca-Astarte crenata* communities, with standing crops generally less than 100 gm./m^2.

The distribution of these communities can be related to the environmental conditions. In these arctic regions the water at depths greater than 50 m. has permanently low temperatures, which may either be just above 0° C. or below. Ekman[2] calls regions with such temperatures "low-arctic" and "high-arctic" respectively. However, overlying the deep water is an annually insolated layer, the temperatures of which may occasionally rise to 5° C. or more in summer. Low-arctic conditions can, and often do, occur temporarily at the surface over high-arctic deeper water. The two terms can apply to temperature zones arranged vertically in the sea, as well as zoogeographical regions. As such they are convenient for an ecologist to use, but their significance is mainly as a guide to the temperatures; they imply nothing about the dynamics of the oceanographic conditions, unlike other systems of naming the arctic marine regions[3].

The *Macoma calcarea* communities have only been found where sea temperatures are permanently or seasonally low-arctic. Thus they occur in surface insolated water in the regions farthest north, but may extend deeper elsewhere, for example, Spitsbergen, Iceland[1]. They have a wide geographical range, apparently because some of the component species can adapt their breeding season to the time of year when appropriate temperatures occur, namely, in summer in the Arctic, in winter in warmer areas. The *Venus fluctuosa* and the *Portlandia arctica* communities appear to be restricted to certain bottom sediments within the low-arctic environment: types of coarse sand and fine mud, respectively. The *Chiridothea sabini* communities have only been found in two localities, in which the most obvious common environmental factor is very low summer temperature, that is to say, permanently high-arctic. The two deeper water communities occur below the depths affected by insolation where temperatures may be either low- or high-arctic.

Scattered dredge collections from Greenland to Alaska suggest that communities of *Macoma calcarea* are very widely spread in shallow water throughout arctic North America, but are replaced by other communities in deeper water. This pattern of vertical zonation appears to be very common.

An account of the collections and a more detailed discussion of the ecological and zoogeographical concepts mentioned here is being prepared for publication. Tables listing the species collected, and their numbers and weights per grab haul, are included in a doctoral thesis[4] deposited in the Redpath Library, McGill University, Montreal.

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[1] Thorson, G., in "Treatise of Marine Ecology and Paleoecology", 1, Chapter 17, p. 461 (Geol. Soc. Amer., Mem. 67, 1957).

[2] Ekman, S., "Zoogeography of the Sea" (1953).

[3] Dunbar, M. J., Fish. Res. Bd. Canad., Bull., 88 (1951).

[4] Ellis D. V., "Marine Infaunal Benthos in Arctic North America", Ph.D. thesis, McGill University, Montreal (1957).

CYTOLOGY

Nuclear Deoxyribonucleic Acid Content and Endopolyploidy in the Meristem of Onion Roots

PHOTOMETRIC analysis of the deoxyribonucleic acid content of nuclei would afford an interesting approach to the problems connected with polyploidy, polyteny and endomitosis, our knowledge of which is still fragmentary. It would also help us to understand the evolutionary processes and trace the relationships of species. If, in accordance with the hypothesis of deoxyribonucleic acid constancy, there is a strict correlation between the deoxyribonucleic acid content and the number of chromosomes, or more exactly the number of chromonemata, measurement of deoxyribonucleic acid would be the easiest way of studying polyploidy, polyteny and endomitosis, particularly in the interphase or prophase nuclei where the chromosome numbers cannot be counted. Evolutionary processes involving polyploidization from one species to another close one can be traced by means of photometric analysis, as the deoxyribonucleic acid content of the sperm or of the normal diploid nucleus appears to be characteristic of a species. The utilization of deoxyribonucleic acid content in problems of evolution is well illustrated by Hughes-Schrader's[1] work on a number of closely related species of mantids the karyotypes of which are not analysable by the usual methods of comparative cytology. The deoxyribonucleic acid content of the spermatids of two species, one having twice the number of chromosomes as the other, was the same, agreeing well with cytological studies which led to the conclusion that redistribution of chromosomal material rather than polyploidy was involved in the evolution of these species. On the other hand, in two other close species the deoxyribonucleic acid ratio of the spermatids was very near 1 : 2, indicating that polyploidy had played a part in their evolution.

During the course of studies on the deoxyribonucleic acid content of nuclei in the meristem of onion roots[6] in one of the central rows of cells which later become central vessels an unusual prophase was found in one of the roots. Each of its chromosomes showed very distinctly two relationally coiled strands. In these sections of roots fixed in acetic acid/alcohol (1 : 3) pairs of sister chromatids at prophase usually appear as single strands. Each strand in this exceptional prophase, furthermore, corresponded in thickness to a whole chromosome of a normal mid-prophase, and the former can be identified as a mid-prophase by the length and relic coiling of the chromosomes. No doubt this nucleus has a diploid complement of chromosomes with four, instead of two, chromatids each. Judged by the number of genomes, such a nucleus is essentially tetraploid. This prophase nucleus happened to be completely, or practically completely, within the section (15μ thick) in spite of its large volume of $3,638\mu^3$ (as compared with 903–$1,004\mu^3$ found in diploid mid-prophases). (The volume in μ^3 was computed as $V = 2hA/3$ where A is area in μ^2 of the largest cross-section of the nucleus measured by a planimeter from a camera lucida drawing, and h is height in μ found as the average difference of four pairs of readings from the microscope fine-adjustment screw.) The deoxyribonucleic acid content measured in arbitrary units, according to the two wave-length method of Patau[3] with modifications[6] was $\gamma = 46{\cdot}34$, almost exactly twice the mean obtained from seven diploid prophase nuclei ($\bar{\gamma} = 22{\cdot}88 \pm 0{\cdot}44$) which is here taken as the best estimate of $4C$.

Similar tetraploid prophases have, of course, been observed before in differentiated root tissue (for example, in great numbers in *Rhoeo* roots treated with indoleacetic acid[2]). What makes the present nucleus highly unusual is its location well within the meristematic part of the root. It is, however, a region in which the cells of the central rows do not ordinarily divide any more; instead, many or most of the nuclei in these rows step up their deoxyribonucleic acid content to what must be about $8C$ or more as judged by their striking combination of large size and intense staining. One of these was measured.

The value obtained, $\gamma = 41 \cdot 35$, is somewhat less than 8*C*. It probably had not finished synthesizing deoxyribonucleic acid. In sections of 15μ most of these nuclei are cut, so that when choosing the nucleus to be measured selection for small volume was inevitable. This nucleus was $1,534\mu^3$, much less than the volume of the tetraploid prophase nucleus and almost the same as the volume, $1,569\mu^3$, of a 4*C* interphase nucleus ($\gamma = 22 \cdot 87$) which was also found in a central cell row. A volume of $1,534\mu^3$ falls well outside the range of interphase nuclei of the diploid mitotic cycle. Lying in a central cell row this nucleus may have been approaching another deoxyribonucleic acid synthesis. In that event it would be more proper to call the nucleus a tetraploid interphase I rather than a diploid interphase III. (During deoxyribonucleic acid synthesis an interphase I with the deoxyribonucleic acid content 2*C* is followed by an interphase II with intermediate deoxyribonucleic acid content, and this by an interphase III with deoxyribonucleic acid content 4*C*.) The ambiguity of interpreting deoxyribonucleic acid classes in terms of polyploidy has already been stressed by Patau and Swift[5]. What can presumably safely be said in the case, say, of an 8*C* interphase is that such a nucleus must be at least a tetraploid and no more than octoploid. In central cell rows within the meristem, though in its proximal part, the nuclear deoxyribonucleic acid content is occasionally stepped up still further. These nuclei are usually too large to be included in one section. The two cut parts (identified by their position relative to eight surrounding nuclei which were also cut) of one such nucleus in neighbouring sections were measured separately. The total deoxyribonucleic acid content $\gamma = 81 \cdot 56$ is 11 per cent less than 16*C*. The difference could again be plausibly ascribed to uncompleted deoxyribonucleic acid synthesis, as the volume, $4,575\mu^3$, of this interphase nucleus was not much more than that of the 8*C* prophase.

It is noteworthy that the appearance of deoxyribonucleic acid values higher than 4*C* in the central cell row is accompanied by an almost complete disappearance of mitotic nuclei. The tetraploid prophase was the only exception observed. All other nuclei were clearly at interphase. In these cells, contrary to those of the surrounding tissue, the initiation of mitosis has been blocked, but deoxyribonucleic acid synthesis has not. Precisely the opposite situation was found by Patau[4] in the corresponding cell rows of *Rhoeo*. In these, mitotic activity also stops long before it ends in the surrounding tissue, but deoxyribonucleic acid synthesis is blocked even earlier, for, in these rows (not only in the proximal meristem but also in the elongation zone) all but a very few nuclei have the deoxyribonucleic acid content 2*C*. This means that the great majority of nuclei after their last deoxyribonucleic acid synthesis still underwent a mitosis, as this is presumably the only process capable of halving the deoxyribonucleic acid content. The fact that either of the two processes—deoxyribonucleic acid synthesis and mitosis—may be blocked first characterizes them as essentially independent of each other, even though a normal mitosis presupposes a previous deoxyribonucleic acid synthesis.

It is concluded that in central cell rows of onion roots, mitotic activity ceases deep in the meristem. Instead, endopolyploidy develops, with the deoxyribonucleic acid content going up to 8*C* or even 16*C*. One quite exceptional prophase was found in a central cell row in the meristem that presumably had the diploid number of chromosomes, with four instead of two chromatids. Its deoxyribonucleic acid content was 8*C*.

This investigation was supported by grants to the late Dr. C. Leonard Huskins from the American Cancer Society upon recommendation of the National Research Council Committee on Growth, from the Rockefeller Foundation and from the Research Committee of the Graduate School, University of Wisconsin, with funds supplied by the Wisconsin Alumni Research Foundation. My thanks are due to Dr. K. Patau for guidance.

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[1] Hughes-Schrader, S., *Biol. Bull.*, **100**, 178 (1951).
[2] Huskins, C. L., and Steinitz, L. M., *J. Heredity*, **39**, 35 (1948).
[3] Patau, K., *Chromosoma*, **5**, 341 (1952a).
[4] Patau, K., *Rec. Gen. Soc. Amer.*, **21**, 56 (1952b).
[5] Patau, K., and Swift, H., *Chromosoma*, **6**, 149 (1953).
[6] Srinivasachar, D., Ph.D. thesis, University of Wisconsin (1953).

A Partial Chemical Characterization of Maize Coleoptile Cell Walls prepared with the Aid of a Continually Renewable Filter

The present work was undertaken with the objective (*a*) of preparing plant cell-wall fragments free of contamination by intact cells, cytoplasm, plastids and other cell inclusions, but containing most of the constituents of the cell wall, including proteins, and (*b*) of characterizing such a cell-wall fraction chemically. The procedure differed from those previously reported in that a filtration technique was employed for purification of the cell-wall fragments and in that isolation was accomplished in an essentially non-aqueous media. It is believed that the filtration technique may prove generally useful in the preparation of cellular components where purification by differential or gradient centrifugation proves impossible. Previous reports of the chemical composition of plant cell-wall tissue have been based on the residue remaining after extraction of tissue macerates with water[1]. Such residues undoubtedly contain particulate cellular inclusions.

Maize (*Zea mays*) coleoptiles were chosen for the present study because of the information already available regarding coleoptile tissue. The coleoptiles were excised from 5-day-old seedlings of Michigan 350 hybrid maize which had been germinated at 25° C. and 90 per cent relative humidity. 25 gm. of the coleoptile tissue were homogenized (Servall 'Omnimixer') for 10 min. at 16,000 r.p.m. together with 180 ml. of glycerol and 37 gm. of glass beads 200μ in diameter (Minnesota Mining and Manufacturing Company, Saint Paul, Minnesota). The homogenate so obtained was permitted to stand for $\frac{1}{2}$ hr. during which time the bulk of the beads settled out. The supernatant fluid (Fig. 1*A*) was decanted into a 150-ml. coarse-porosity sintered glass funnel containing a filter-bed consisting of 1 cm. of the 200-μ glass beads. Filtration was accomplished at the suction pump with continual stirring at gradually increasing depth in the glass-bead filter so as to prevent mat formation. Plastids, nuclei, mitochondria and soluble protein appeared in the filtrate while the cell walls remained in the glass-bead filter-

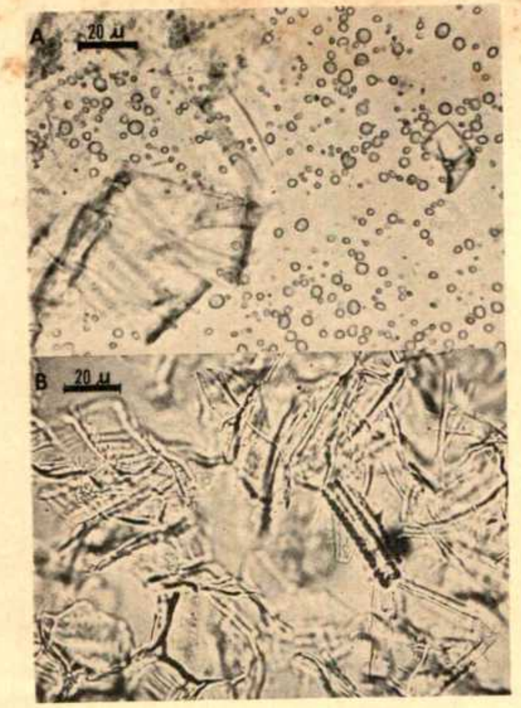

Fig. 1. Photomicrographs of cell-wall preparations at two stages of purification: *A*, crude homogenate showing cell-wall fragments and plastids; *B*, purified cell-wall fragments after fourth filtration

mat. The beads together with cell-wall material were resuspended in 50 ml. of glycerol and the mixture again allowed to settle for ½ hr. The supernatant fluid containing the suspended cell walls was again decanted into a fresh glass-bead funnel and the filtration and settling procedure repeated three times. After the last resuspension, the beads were again allowed to settle and the traces of beads remaining removed by centrifugation for 5 min. at 500*g*. The cell-wall material was then collected as a pellet by centrifugation at 25,000*g* for ½ hr. Purified cell-wall preparations so obtained constitute about 5 per cent of the initial dry weight of the corn coleoptile tissue and are practically free of microscopically visible and histochemically detectable cell inclusions as shown in Fig. 1*B*. If the filtration fluids are reworked until all visible cell-wall fragments have been removed, a yield of 20 per cent of the coleoptile dry weight is obtained. For chemical analysis, the cell-wall material was washed free of glycerol by suspension and resedimentation five times in a ten-fold volume of absolute alcohol and dried to constant weight.

The results of analysis of cell-wall preparations and of whole dried coleoptile tissue are presented and compared with those of other authors in Table 1. To our knowledge, no previous reports of the sulphur, calcium or magnesium contents of primary cell-wall tissue have been published. In general our results are in accord with previously published values with the notable exception of the protein content of the cell walls. Thimann and Bonner reported 12 per cent protein for *Avena* coleoptile (corresponding to 1·9 per cent nitrogen) while Nakamura and Hess reported 30·4 per cent protein for a water-insoluble fraction of maize coleoptile. In the present work, protein, calculated from the nitrogen determinations, would be 2·5–5·1 per cent. Probably the higher values previously reported are due to a greater degree of

Table 1. COMPOSITION OF COLEOPTILE AND CELL-WALL PREPARATIO OF COLEOPTILE OF *Zea* AND *Avena*[*]

	Whole coleoptile (per cent dry weight)	Coleoptile cell-wall (per cent dry weight)
Ash	4·1, 4·4†	0·6, 1·3†
C	—	45
H	—	7
N	4·1	0·4–0·8, 4·9‡
P	0·8	0·03, 0·06‡
S	0·25	0·07
Ca	0·05	0·06
Mg	0·15	0·07
Protein	25·5, 15·2†, 3·1§	2·5–5·1, 30·4‡, 12§, 9·5
Cellulose	14·2, 13·2†, 10·1‡, 11·9§	27·4, 32·7†, 42§, 24·8¶
Pectin	4·0†, 2·3§	8·4, 10·2†, 8§, 0·3¶
Lignin	6·6	5·4
Ribonucleic acid	Less than 0·9	Less than 0·15

[*] We are indebted to Dr. Peter Albersheim for the anhydrouro acid and to Mrs. Mary A. Vacasey for the calcium and magnesi determinations.

† Maize coleoptile (ref. 1*c*).

‡ Maize coleoptile (ref. 1*b*).

§ *Avena* coleoptile (ref. 1*a*).

¶ *Avena* coleoptile (ref. 5).

contamination of the cell-wall preparation by cyt plasmic substances.

A limited characterization of the polysacchari components of the cell wall was made by the gene procedure of Norman[2]. Cellulose was extracted fro the 0·5 per cent ammonium oxalate insoluble cell-w fraction with 72 per cent sulphuric acid after hydrol sis with 2 *N* hydrochloric acid. The extract w diluted to 5 per cent sulphuric acid, hydrolysed, a glucose was determined with the aid of gluco oxidase. By this procedure the cellulose content w calculated to be 27 per cent. The 'pectin fractio as isolated by the usual precipitation method fr ammonium oxalate extracts constituted 28 per ce of the dry weight of the cell-wall preparation. Pa chromatographic examination of the 'pectin fracti following exhaustive methylation and acid hydro sis[3] indicated that only 2–5 per cent of the cell-w weight was polyuronic acid. Since losses of uro acid by this method might be expected, the value 8 per cent obtained by Dr. Albersheim seems corre The ribonucleic acid content of the cell wall w found to be less than 0·15 per cent as determined the method of Ogur and Rosen[4]. This would accou for approximately half the total cell-wall phospho

In summary, our present analysis accounts for o approximately 45 per cent of the cell-wall dry weig Qualitatively, it may be stated that starch a dextrines are absent but there are large amounts pentose and hexose polysaccharides. Further stud of these as yet uncharacterized carbohydrate fr tions and the enzymatic activities of cell-wall fr ments are in progress.

This work was supported in part by the Michig Agricultural Experiment Station and by the Natio Science Foundation.

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[1] *a*, Thimann, K. V., and Bonner, J., *Proc. Roy. Soc.*, B, **113**, 126 (19
b, Nakamura, Y., and Hess, K., *Ber. chem. Ges.*, **71**, 145 (19
c, Wirth, P., *Ber. schw. bot. Ges.*, **56**, 175 (1946).

[2] Norman, A. G., "The Biochemistry of Cellulose the Polyuron Lignin", 232 (Clarendon Press, Oxford, 1937).

[3] Morell, S., Baur, L., and Link, K. P., *J. Biol. Chem.*, **105**, 15 (19

[4] Ogur, M., and Rosen, C., *Arch. Biochem.*, **25**, 262 (1950).

[5] Bishop, C. J., Bayley, S. J., and Setterfield, G., *Plant Physiol.*, 283 (1958).

FORTHCOMING EVENTS

Sunday, September 6—Wednesday, September 9

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (at York) —Continuation of Annual Meeting

Sunday, September 6

At 10 30 a m.—(in York Minster)—Religious Service Preacher The Most Reverend the Lord Archbishop of York

Monday, September 7

At 10 a m —Prof O M B Bulman, F R S "Recent Developnents and Trends in Palæontology" (Presidential Address, Section C)

At 10 a m —Prof Ian A Richmond "The Nature and Scope of Archæology" (Presidential Address, Section H)

At 10 a m —Prof A Hemingway "Artificial Organs—Biological Applications" (Presidential Address, Section I)

At 8 p m —Sir William Hildred "International Air Transport Problems" (Evening Discourse)

Thursday, September 10—Friday, September 11

SOCIETY OF INSTRUMENT TECHNOLOGY (at the Polytechnic, Regent Street, London, W 1), at 9 15 a m Thursday and 10 a m Friday—Education Conference

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or efore the dates mentioned

ASSISTANT LECTURER (with an honours or special degree in psychology or equivalent) IN PSYCHOLOGY—The Secretary, Bedford College University of London), Regent's Park, London, N W 1 (September 4)

LECTURER IN EDUCATION at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British ommonwealth, 36 Gordon Square, London, W C 1 (New Zealand, eptember 20)

LECTURER (with a good honours degree in electrical engineering or hysics, and industrial or research experience in light-current electrical ngineering) IN ELECTRICAL ENGINEERING at Queen's College, Dundee University of St Andrews)—Joint Clerk to the University Court, Queen's College, Dundee (September 28)

ASSISTANT LECTURER IN SOCIAL ADMINISTRATION—The Registrar, The University, Manchester 13 (September 30)

LECTURER IN MATHEMATICS at the University of New England, ustralia—The Secretary, Association of Universities of the British ommonwealth, 36 Gordon Square, London, W C 1 (Australia, eptember 30)

LECTURER IN ZOOLOGY at the University of Queensland, Australia -The Secretary, Association of Universities of the British Commonealth, 36 Gordon Square, London, W C 1 (Australia, September 30)

SENIOR LECTURER IN PHYSICS, a LECTURER IN PHYSICS, and a ECTURER IN SOCIOLOGY at Rhodes University, Grahamstown, South frica—The Secretary, Association of Universities of the British ommonwealth, 36 Gordon Square, London, W C 1 (South Africa, eptember 30)

LECTURER IN GEOGRAPHY at the University of Sydney, Australia—he Secretary, Association of Universities of the British Commonealth, 36 Gordon Square, London, W C 1 (Australia, October 1)

CHAIR OF CHEMISTRY at Bedford College—The Academic Registrar, niversity of London, Senate House, London, W C 1 (October 5)

CHAIR OF PHYSICS in the University of Tasmania—The Secretary, ssociation of Universities of the British Commonwealth, 36 Gordon quare, London, W C 1 (Australia, October 15)

LECTURER or ASSISTANT LECTURER (with special qualifications in hysical chemistry) IN CHEMISTRY—Secretary, The Royal College Science and Technology, Glasgow

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Association of Universities of the British Commonwealth List of University Institutions in the British Commonwealth Fifth edition Pp 8 Students from other Countries in United Kingdom Universities, 1958–59 Pp 2 (London Association of Universities of the British Commonwealth, 1959) [284

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Royal Cornwall Polytechnic Society The One Hundred and Twenty-fifth Annual Report, 1958 Pp 60 (Falmouth Royal Cornwall Polytechnic Society, 1958) [284

Ministry of Agriculture, Fisheries and Food Technical Bulletin No 7 Plant Nematology Edited by J F Southey (Based on the collected lectures from a course held at the N A A S Regional Headquarters, Bristol) Pp vii+175+12 plates (London H M Stationery Office, 1959) 9*s* 6*d* net [284

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Building Research Station Digest No 120, (March,1959) Questions and Answers Pp 6 (London H M Stationery Office,1959) 4*d* [284

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Association of British Pharmaceutical Industry Annual Report and Year Book, 1958–59 Pp 48 (London Association of British Pharmaceutical Industry, 1959) [55

Journal of Molecular Biology, Vol 1, No 1, (April 1959) Pp 86 Published six times per annum Vol 1, 1959, 100*s* (14 dollars)

(London Academic Press, Ltd New York Academic Press, Inc , 1959) [55

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Institut Royal Météorologique de Belgique Contributions No 48 La Thermosphère Par Dr Marcel Nicolet Pp 22 No 49 Remarques a propos d'une Généralisation de l'Indice de Similitude de M Boulét Par Dr R Sneyers Pp 10 Publications Série A, No 9 Annuaire Climatologique pour 1957 Pp 94 (Uccle-Bruxelles Institut Royal Météorologique de Belgique, 1959) [284

Canada National Research Council Division of Building Research Technical Paper No 62 Building in Northern Canada By R F Legget and H B Dickens Pp vi+41 (Ottawa National Research Council, 1959) 75 cents [284

Canada Department of Mines and Technical Surveys Dominion Observatories Publications of the Dominion Observatory, Ottawa Vol 20, No 2 The Mechanics of Faulting, with special reference to the Fault-Plane Work—a Symposium Edited by John H Hodgson Pp ii+251–418 (Ottawa Queen's Printer, 1959) 3 dollars [284

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge Carte des Sols et de la Vegetation du Congo Belge et Ruanda-Urundi 12 Bengamisa A Sols C Utilisation des Sols Notice Explicative de la Carte des Sols Par A Van Wambeke Pp 47 (Bruxelles Institut National pour l'Étude Agronomique du Congo Belge, 1958) [284

Organization for European Economic Co-operation Statistical Bulletins Agricultural and Food Statistics Pp vi+130 (Paris Organization for European Economic Co-operation , London H M Stationery Office, 1959) 700 French francs , 12*s* , 2 dollars [284

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Berichte des Deutschen Wetterdienstes Nr 50, (Band 7) Untersuchungen Reliefbedingter Kleinklimatischer Fragen in Geländequerschnitten der Hochmontanen und Montanen Stufe des Mittel- und Sudwestharzes Von F K Hartmann, J van Eimern und Gisela Jahn Pp 40 6 90 D M Nr 51 (Band 7) Die , Meteorologische Tagung in Garmisch-Partenkirchen vom 17 bis 19 Oktober 1958 Pp 114 24 D M Nr 52, (Band 7) Sichweite und Bewölkung an Deutschen Verkehrsflughafen Von Hans Guss Pp 58 (Offenbach a M Deutschen Wetterdienstes, 1959) [284

Rubber Research Institute of Malaya Annual Report 1955 Pp 85 (Kuala Lumpur Rubber Research Institute of Malaya, 1959) 3 dollars [284

United States Department of Agriculture Production Research Report No 25 Estimations of Wind Erodibility of Farm Fields By W S Chepil and N P Woodruff Pp 22 (18 photographs) (Washington, D C Government Printing Office, 1959) 15 cents [284

Académie Polonaise des Sciences Centre de Cracovie *Acta Biologica Cracoviensia* Série Botanique, Vol 1, No 1, Janvier-Mars, 1958 Pp 56+8 plates Cena zl 26 Série Zoologie, Vol 1, No 1, Janvier-Mai, 1958 Pp 34+6 plates Cena zl 7 50 (Cracovie Imprimerie de l'Université, 1958 and 1959) [284

Smithsonian Institution Bureau of American Ethnology Bulletin 170 Excavations at La Venta, Tabasco, 1955 By Philip Drucker, Robert F Heizer and Robert J Squier With Appendices by Jonas E Gullberg, Garniss H Curtis and A Starker Leopold Pp viii+312+63 plates (Washington, D C Government Printing Office, 1959) n p [284

Institut Royal des Sciences Naturelles de Belgique Expédition Océanographique Belge dans les Eaux Côtières Africaines de l'Atlantique Sud (1948–1949) Résultats Scientifiques Vol 3, Fascicule 5 Porcellanid Crabs By Fenner A Chace Copépodes Parasites Par André Capart Pp 126 (Bruxelles Institut Royal des Sciences Naturelles de Belgique, 1959) [284

European Productivity Agency of the Organization for European Economic Co-operation Fitting the Job to the Worker a Survey of American and European Research into Working Conditions Industry—Heat and Cold , Human Fatigue , Machine Desig Mental Stress , Noise , Physical Health , Speed and Proficienc (Report on a Mission to the United States, 5 Sept -3 Nov 195 and on the Leyden Seminar 29 March–3 April 1957) Pp 170 (Par European Productivity Agency of the Organization for Europe Economic Co-operation , London H M Stationery Office, 195 800 French francs , 14*s* , 2 50 dollars [2

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Seventy-fifth Annual Report of the Bureau of American Ethnolo to the Secretary of the Smithsonian Institution, 1957–1958 Pp i 36+5 plates (Washington, D C Government Printing Offi 1959) [

American Philosophical Society Year Book 1958 Pp 652 (Phi delphia American Philosophical Society, 1959) [

Work carried Out under the Auspices of the Indian National Co mittee for the I G Y , 1957–1958 (Issued on the Occasion of t Sixtieth Birthday of Dr K S Krishnan, F R S) Pp vi+110 (printed from the *Journal of Scientific and Industrial Research*, Vol 1 No 12, 1958) (New Delhi Indian National Committee for t International Geophysical Year, 1958) [

Durban Museum Novitates Vol 5, Part 12 Miscellaneous Tax nomic Notes on African Birds 1 Geographical Variation in t Narina Trogon *Apaloderma narina* (Stephens) of Africa By P Clancey Pp 151–179 5*s* net Vol 5, Part 13 Eine Neue Dip nevra (S Str) (Dpit Phor) aus Natal Von Erwin Matthias Bey Pp 181–183 1*s* net (Durban Durban Museum, 1959) [

Tanganyika Records of the Geological Survey of Tanganyi Vol 6, 1956 Pp iii+102+13 plates (Dar-es-Salaam Governme Printer, 1958) Shs 17/50 [

Museum of Comparative Zoology at Harvard College Brevio No 101, (March 2, 1959) Cervical Ribs in Turtles By Ernest Williams Pp 12+1 plate Bulletin of the Museum of Comparati Zoology at Harvard College Vol 119, No 8 Studies on the M phology and Function of the Skull in the Boidae (Serpentes) Part Cranial Differences between *Python sebae* and *Epicrates cenchr* By T H Frazzetta Pp 451–472 Vol 119, No 9 The Genus *Tet gnatha* (Araneae, Argiopidae) in Michigan By Arthur M Chickeri Pp 473–499 Vol 120, No 1 The herpetology of Southern Rhodes Part 1 Snakes By Donald G Broadley Pp 1–100+6 plates V 120, No 2 Studies on the Comparative Embryology of the Reptili Nose By Thomas S Parsons Pp 101–277+7 plates (Cambrid Mass Museum of Comparative Zoology at Harvard College, 1959) [

International Nickel Company of Canada Limited Address Shareholders, Annual Meeting, April 29, 1959 By John F Thomps Pp 16 (Copper Cliff, Ontario International Nickel Company Canada, Ltd , 1959) [

Uganda Protectorate Annual Report of the Geological Surv Department for the year ended 31st December, 1958 Pp i+1 (Entebbe Government Printer, 1959) Shs 2 [

Medical Education Annotated Bibliography, 1946–1955 Pp 3 (Geneva World Health Organization , London H M Statione Office, 1958) 20 Swiss francs , 35*s* , 6 75 dollars [

Bulletin of the American Museum of Natural History Vol 1 Article 1 The Cuban Edentates By William Diller Matthew a Carlos de Paula Couto Pp 1–56+plates 1–42 (New York Americ Museum of Natural History 1959) 2 50 dollars [

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EDUCATIONAL PROBLEMS OF THE COMMONWEALTH

SEVERAL recent events of great public importance have received little or no public discussion, due resumably to the stoppage in the printing industry n Great Britain Among these events the Commonvealth Education Conference, which met in Oxford uring July 15–29, is outstanding As the Secretary f State for Commonwealth Relations, Lord Home, tated in the House of Lords on July 2, this Conerence was called primarily to work out detailed rrangements for the new scheme for a thousand ommonwealth scholarships and fellowships, which vas agreed upon by Commonwealth Ministers at the Trade and Economic Conference held in Montreal in eptember 1958 The Conference, however, was also o review existing arrangements for co-operation etween the Commonwealth countries on education enerally, and although it was to settle its own genda, Lord Home indicated that the supply and raining of teachers and scientific and technical ducation would be subjects of particular importance

In making this statement, Lord Home expressed he hope that from the Conference there would merge practical schemes for furthering co-operation n this vitally important matter of education, where he needs are so great and where Commonwealth ountries have so much to offer one another Lord ome emphasized, too, the high standing of the ommonwealth representatives at the Conference, of vhich Lord Halifax was president and Sir Philip orris was chairman, and he referred also to the even study tours of the United Kingdom, designed o give the delegates a balanced insight into our resent system and its working, one of which each verseas delegate would make before the Conference pened The contribution of the United Kingdom in ommonwealth education is also described in a booket prepared specially for the Conference by the entral Office of Information (Hercules House, Vestminster Bridge Road, London, S E 1)

The simple fact, to which also Lord Home directed ttention on July 3, that any schemes which the onference might propose would almost inevitably nvolve money, sufficiently indicates the importance f wide and informed public discussion of the whole ubject The magnitude of the contribution which ritain is already making in this field must be fully nderstood, both in Britain and in the Commonvealth, and the implications elsewhere in terms of an-power, even more than in terms of material or nancial resources, if the proposals of the Conference re to be correctly appraised, still more if the resources equired are to be forthcoming There can be few ubjects which better illustrate the bearing of inormed discussion on the functioning of democratic nstitutions, as there are also few in which party olitics could be more damaging or dangerous. ndeed over wide areas, and especially in Africa, he success of self-government and the survival of democratic institutions may largely depend on our success in solving the problems involved in the expansion of education, especially secondary education, and in reconciling the clash between the comparatively slow, healthy growth in educational institutions and the mounting demand for rapid political change

In opening the Conference on July 15, the Earl of Halifax stressed the practical objectives of the Conference, and pointed out that to-day it is a question of the right sort of education at the right time Freedom itself will depend upon the education we are now providing for our young people, both because of the technical skills that education can provide and because of the qualities of character and mind that go with it Lord Home, in a speech on the opening night of the Conference, referred to the importance of the common pattern of education in the Commonwealth and the practical co-operation on which it is based, both in relation to the particular objectives of the Conference itself and in the wider context of the promotion of international understanding, to which the interchange of teachers and students could make a most effective contribution

Speaking in the House of Lords on July 29, Lord Home claimed that the Conference had been an outstanding success In the ten working days at Oxford, plans had been made not only to bring into operation the Commonwealth scholarship scheme approved in principle at Montreal, but also to provide for both short- and long-term assistance to those Commonwealth countries where a shortage of teachers at all levels is holding up the development of education and the progress of the economy The scholarship scheme itself will cost about £5 million during the first five-year period, of which the 500 scholarships provided by the United Kingdom will take about half With the 250 offered by Canada, 100 each by India and Australia, 30 by Pakistan, 25 by New Zealand, 12 each by Malaya and Nigeria, 10 each by Ghana and Rhodesia and Nyasaland, 6 by Ceylon and 4 by East Africa, the target of 1,000 scholarships is already exceeded For the most part the scholarships will be given to graduates for research or work for higher degrees in universities and comparable institutions in other Commonwealth countries than their own, and the scholarships will be tenable for an average period of two years and be comparable in standing with the best offered by any other country or in any other way

A small number of visiting fellowships to enable distinguished Commonwealth professors to visit other Commonwealth countries and to work at institutions of their own choice will supplement the scholarships, and a few scholarships will also be tenable at the undergraduate-level where the courses required by the candidates are not available in their own countries It may be recalled that the United Kingdom has already contributed in grants and loans under the Colonial Development and Welfare Acts some £13 million to higher education, and that there were in 1958–59 more than 7,000 full-time students from other parts of the Commonwealth enrolled in universities of the United Kingdom with some 6,600 students in technical colleges, and of these some 250 were trainees under the Colombo Plan, so that the new scheme is only an extension in scale , and Lord Home pointed out in the House of Lords that the Conference itself recognized that it was only making a start on the most urgent and specific needs It therefore recommended that another Commonwealth Education Conference should meet in 1961 to review progress and to make further plans

Lord Home's statement in the House of Lords showed that the Conference also frankly recognized that the most serious problem is that of teachers, and especially of those qualified to teach in the secondary schools, and that this special need of the emergent countries can only be met by special efforts on the part of the senior members of the Commonwealth The United Kingdom is already sending some 2,500 teachers a year to Commonwealth countries, but the Conference estimated that about a thousand more teachers are wanted each year for secondary schools, and two hundred for technical schools , in addition, 500 are wanted at once for teacher-training colleges

Lord Home said, quite correctly, that in the short run the quickest way is to send out teachers already trained to occupy key posts overseas, and this the older Commonwealth countries are proposing to do University lecturers and professors would be encouraged to take up overseas posts, and in the United Kingdom a special effort will be made to help with teachers in those scientific and engineering subjects in which Commonwealth countries have reported their needs are greatest These subjects are, of course, those where the shortage of teachers is felt acutely in the United Kingdom, and Lord Home commented that, if the objective is to be achieved, administrative measures will be necessary including the topping-up of salaries calculated on the local scale, the provision of passages for the teacher and his family, preservation of his pension rights and promotion prospects and assistance in resettlement on return In promising the Conference that the British Government would help with such measures, Lord Home appealed also to teachers to respond to the challenge presented to men and women of talent, imagination and sympathy

The United Kingdom proposals provide for some four hundred additional United Kingdom teachers to serve in Commonwealth countries, but the long-term solution must be to build up the educational resources of the smaller Commonwealth countries by providing the staffs for new teacher-training institutions which they may decide to establish, either in their own territory or jointly to serve the needs of a particular region Accordingly, said Lord Home, we would provide in the United Kingdom five hundred more places for teacher trainees from those countries as from the academic year 1960–61, and £250,000 a year for grants to the students occupying them There were already, in 1958–59, 728 Commonwealth students training as teachers in the United Kingdom and if, as Lord Home stated, Canada, Australia, New Zealand, India and other countries make considerable contributions, the position should be significantly improved when the next Conference meets

The expansion of technical education will take time, but here also the Conference has initiated new efforts to speed the process The need for trained teachers in technical subjects, the continuing need for industrial training and the great shortage of suitable books and equipment were all emphasized In the United Kingdom, it is planned that during the next ten years some 4,000 additional places will be available to the Commonwealth students in technical colleges The Federation of British Industries and the industrial research associations have already indicated their intention to continue the facilities now offered to overseas students and to expand them in certain directions

These further projects discussed at the Conference are estimated to cost at least a further £5 million during the next five years, of which the United Kingdom contribution will be about £3 5 million, making a contribution of some £6 million out of the total of at least £10 million This, as Lord Home observed, is a substantial contribution, and it does not stand alone Indeed, it is not easy to estimate the full financial magnitude of the United Kingdom contribution to Commonwealth education even at the university-level Account has to be taken of what is being done through the British Council, the Nuffield Foundation and like institutions, and through the Commonwealth University Interchange scheme

Even if the financial magnitude of the British contribution could be accurately assessed, this is possibly the least important aspect Compared with the magnitude of expenditure on education in Britain alone—estimated as likely to exceed £1,000 million within the next decade—it is relatively trivial, and it is small also in comparison with expenditure in Britain on scientific and industrial research, with which it is so closely connected Essential as it is that adequate financial resources should be available for Commonwealth education, man-power is the decisive factor, and it is imperative that financial resources should be wisely applied so as to remove so far as possible all obstacles to the free interchange of students and teachers The benefits of such movement are reciprocal, and the Conference should at least have emphasized that in such wandering scholars the Commonwealth has one of its most valuable assets

On that there are perhaps two points of special interest at the present time Prof Kenneth Robinson has directed attention to the value of extending interchange to research and to the need for research fellowships and studentships which would enable young United Kingdom graduates to spend a year or two in one of the other countries of the Commonwealth, studying some aspect of the history, culture or contemporary social, political or economic problems of that country There are, he claims, many urgent and important pieces of research in this field which young United Kingdom graduates cannot at present be encouraged to undertake because of the lack of opportunity to spend the necessary time in the Commonwealth country concerned Such work is at present often done by Americans, although the Nuffield Foundation has supported some such studies and the Commonwealth universities are fully alive to the value of such Rhodes scholarships in reverse Nevertheless, there is an undoubted need for a rapid extension and increase of funds and facilities enabling United Kingdom graduates to spend substantial periods on research work overseas, and it should not be forgotten that a further beneficial result would be to build up in Britain a growing corps of graduates who would have first-hand knowledge of the problems and culture of other parts of the Commonwealth

The second and even more urgent point is that of the supply of teachers, and especially secondary school teachers Prof Arthur Lewis, when economic adviser to the Ghana Government, estimated that countries emerging from Colonial status are not self-sufficient in secondary school teachers until about 4 per cent of each generation is entering the secondary schools Only in Western Nigeria is this proportion reached, though in Ghana great efforts are being made in the current development plan to exceed the present 2 per cent Many other territories, such as Kenya, Nyasaland and Northern Nigeria, are far behind; and although in some territories the primary school numbers are creditable, until comparatively recently there has been practically no secondary education in many areas.

What the Commonwealth Education Conference has emphasized above all is that advance in education depends not only on sufficient financial resources but still more on foresight, patience and sacrifice Teachers of the calibre demanded for secondary schools, especially for work in the sixth forms, are not to be found overnight Their training calls for tutors of high calibre, and time to complete that training not simply in secondary courses but also n teachers' training courses and sometimes to graduate-level in university institutions

This is the real—and the key—problem in education for the emergent territories, and it is only indirectly and in the long term that the scholarship scheme at the university-level will contribute to its solution Meanwhile, the emergent territories depend on the older members of the Commonwealth for the help essential to build up as rapidly as possible ystems of secondary education capable of meeting he demands for emergent nationhood Financially, his is bound to involve expenditure far in excess of the £10 million immediately contemplated at the Commonwealth Education Conference, including apital expenditure as well as grants for recurrent xpenditure on secondary education, while an even greater strain may be put on the human resources f the Commonwealth

Of this Lord Home was manifestly conscious in his appeal, at the closing of the Conference, so far as higher education is concerned, and it is no less true of secondary education Most of the senior members of the Commonwealth are themselves short of secondary school teachers—in some the shortage is a result of the racial policies pursued by them—and special measures are already being concerted in the United Kingdom to meet the situation arising as 'the bulge' approaches our sixth forms The measures promised by Lord Home may help to increase the numbers of teachers which we already send to Commonwealth countries, though it may still be necessary to explore other possible emergency measures which changes in our economy may offer These alone will not suffice, however, without the imaginative response and enthusiasm for which Lord Home appealed To create the public and professional understanding on which such a response can be soundly based is an urgent and primary task for which the Government has a primary responsibility For this reason it is imperative to expedite as much as possible the publication of the full report of the Conference, and ensure that it is widely discussed both in Parliament and outside

BERTRAND RUSSELL, PHILOSOPHER

My Philosophical Development

By Bertrand Russell Pp 279 (London George Allen and Unwin, Ltd, 1959) 18*s* net

ALL those whose study of philosophy is grounded in the empirical tradition regard Lord Russell as the greatest living philosopher His philosophizing started in the 'nineties when philosophy in Britain, in Europe and most of the United States was dominated by idealisms deriving either from Hegel or from Kant After a few years as a "full-fledged Hegelian" (p 42), Russell tells us that in 1898 both G E Moore and he "rebelled against both Kant and Hegel" (p 54) From this rebellion sprang the current of empiricist or 'scientific' or 'analytic' philosophy which to-day, in one form or another, dominates philosophical thinking and teaching throughout the English-speaking world and plays an important part in the pattern of our contemporary culture Although one should not neglect other influences—in particular, that of Moore, of Frege, of the Polish philosophers, of C S Peirce and the American pragmatists, and of the greatest of Russell's pupils Wittgenstein (about whom there is a good deal in this book)—there is no doubt that the main responsibility for the present state of philosophy lies squarely on Russell's shoulders Without his work in the first quarter of this century it is difficult to see how the logical positivist movement could have arisen, and, if philosophers' interest in the use of language had developed independently of analytic philosophy, it would have taken a much less realist form Russell's influence has been largely due to his immense fertility of ideas, and to his willingness to publish them even though he might later have to retract or modify his conclusions There are few philosophers in history who have written important philosophical works almost continuously for fifty years Russell has added to the immense debt we owe him by now giving us a full-scale account of his philosophical development, written with all the clarity, verve and wit we are accustomed to expect from anything he writes

"My philosophical development," Russell starts the book by saying, "may be divided into various stages according to the problems with which I have been concerned and the men whose work has influenced me There is only one constant preoccupation I have throughout been anxious to discover how much we can be said to know and with what degree of certainty or doubtfulness" (p 11) Considering rational bases for geometry and for mechanics led Russell back to arithmetic , and four chapters of this book are devoted to general questions involved in his attempt to derive mathematics from logic, which culminated in Whitehead and Russell's "Principia Mathematica" Russell gives a lucid informal account of the logical paradoxes which caused him so much trouble, and of the theory of types which he invented in 1908 to solve them Though systems of mathematical logic have been constructed recently which do not explicitly make use of distinctions of type in Russell's manner, they almost all presuppose restrictions upon the use of symbols which are virtually equivalent to a type theory The philosophical insight in Russell's theory is that a sentence may be perfectly well constructed according to grammatical rules and yet lack meaning there are logical restrictions upon the significant combination of symbols as well as purely grammatical ones The emphasis later laid by logical positivists upon the nonsensicality of many apparently sensible expressions was foreshadowed in Russell's theory of types (see pp 14, 160)

After 1910 Russell turned his attention to theory of knowledge, and in 1914 put forward his well-known programme of substituting, so far as possible, logical constructions for inferred entities This programme, and the similar 'operationalist' programme advanced by P W Bridgman in 1927, has made great appeal to philosophers of science, many of whom have attempted to apply it to the construction of various scientific concepts In this book Russell says that he "soon became persuaded that this is an impossible programme and that physical objects cannot be interpreted as structures composed of elements actually experienced" (p 105) I do not think that Russell ever published his reasons for his change of view cogent reasons for the impossibility of the logical construction programme were first given by F P Ramsey in 1931 In Russell's later writings, and in this book, similarity of structure is taken as being the connecting link between the electromagnetic waves used in broadcasting and auditory sensations (p 204) Though Russell speaks (not very happily, I think) of scientific knowledge using "artificially manufactured entities", "real or supposed entities", "scientific abstractions" (pp 205–6), "constructions composed of events and taken as units for the convenience of the mathematician" (p 27), he would not now regard these as having to be given, directly or indirectly, in terms of experience "I cannot see that there is any ground whatever for this opinion [that there can be nothing which is not experienced or experience], nor even for the view that we cannot know that there are things we do not know" (p 144)

Other problems with which Russell has been concerned and which he treats in this book are those of consciousness and perception, of non-demonstrative inference, of truth, of names and of language i general With regard to language, Russell recount how he moved from regarding it as "transparent" t realizing its philosophical importance Nevertheles "the essential thing about language is that it ha meaning—i e , that it is related to something othe than itself, which is, in general, non-linguistic" (p 14) "In regard to truth and falsehood, a sentence is onl important as a vehicle of belief" (p 154) Russel wholly rejects the view that the study of language i an end in itself for a philosopher Nor does he accep any hard and fast separation of philosophy fro science "Philosophy cannot be fruitful if divorce from empirical science" (p 254) Of the outcome o his recent work on inference he says that "the reason for accepting it are the ordinary reasons applied i scientific work, not remote reasons derived from som metaphysical theory There is no claim to certainty" (p 207) In this book Russell does not (as h did in 1914) speak of "scientific method in philosophy", a phrase which may mean anything o nothing But if by the scientific spirit is meant th persistent and single-minded attempt to "understan the world" (p 230) by envisaging bold but tentativ hypotheses without ever losing sight of the facts whic these hypotheses are intended to explain, Russell' work exemplifies this spirit better than does that c any other contemporary philosopher

R B BRAITHWAITE

CATALYSIS

Catalysis

Edited by Paul H Emmett Vol. 5 Hydrogenatio Oxo-Synthesis, Hydrocracking, Hydrodesulphurization, Hydrogen Isotope Exchange and Relate Catalytic Reactions Pp vi+542 (New York Reinhold Publishing Corporation , London Chapman and Hall, Ltd , 1957) 120*s*

Advances in Catalysis and Related Subjects

Edited by Adalbert Farkas Vol 9. Pp xviii+847 (New York Academic Press Inc , London Academic Books, Ltd , 1957) 16 dollars

VOLUME 5 of "Catalysis" continues the description of various hydrogenation processes whic has already extended through the previous tw volumes , and the allotment of so much space, eve in a major treatise on catalysis, is in itself a sig of the importance which this type of reaction ha attained in modern academic and industrial chemistr Following an introductory section on the gener reactivity of carbon monoxide, I Wender, H W Sternberg and M Orchin contribute a well-writte chapter on the high-pressure hydrogenation of mixtures of carbon monoxide and olefines to long-cha ketones by the oxo reaction. In this, considerabl interest is attached to the use of soluble catalyst derived from cobalt or nickel carbonyls since, in th way, homogeneous liquid hydrogenation systems ca be obtained A good survey is also given of th general theory of the reaction mechanism involved an of the part played by carbonium ions in this Th next chapter, by G Natta, U Colombo and I Pasquon, deals with the use of promoted mixed-oxid catalysts for the hydrogenation of carbon monoxid to higher aliphatic alcohols and supplements a sectio in an earlier volume on the synthesis of methyl alcoho There is, in this field, abundant scope for the furthe study of the basic mechanism of promoter actio about which relatively little is known in spite of the very large amount of work which has been done on the subject

The long monograph on the hydrogenation of aromatic compounds by H A Smith, who has himself contributed considerably to our knowledge of this subject, stands out as a comprehensive survey and reviews systematically a very large number of papers covering the catalytic reduction of carbocyclic and heterocyclic substances This detailed treatment also occurs in the chapter by T I Taylor on the use of hydrogen isotopes for the detection of subsidiary processes involving hydrogen exchange, bond migration or other reactions which are superimposed on the ydrogenation itself and, in many cases, cannot easily be recognized in other ways In addition, the method throws considerable light on the internal complexity of hydrogenation generally Finally, the article by J B McKinley on the hydrodesulphurization of liquid petroleum fractions gives an authoritative survey of a type of process which has done much to mprove the general quality of commercial motor spirit and which has only become practicable economically by the recent availability of very large quantities of by-product hydrogen derived from ydroforming reactions

In a major work of this type, published with rather long intervals of time between the issue of the individual volumes, it is difficult to avoid some ack of logical sequence for example, the wide separation of the article on the synthesis of higher alcohols in the present volume from that of methyl alcohol in Volume 3, and the chapter on the hydrogenation of aromatic compounds from those on the eduction of olefines and acetylenic derivatives This, however, is a minor criticism , and the work as a whole is to be recommended as an up-to-date treatise on catalysis, which should be of great value to the many chemists who are interested in this subject

The publication, as a volume of "Advances in Catalysis", of the 84 papers which were read at the nternational congress on catalysis held in Philaelphia in 1956 constitutes an alternative policy to he spreading of these contributions in a single and apidly growing field of knowledge among a relatively rge number of individual journals, some of which ay be accessible only with difficulty to chemists orking in smaller institutions In addition, it orms one way of relieving the increasing pressure hich is being felt by some of the various publishing ocieties in providing adequate space for the accomodation of all the otherwise suitable papers now sent n to them

Following introductory addresses by Sir Hugh aylor and by Sir Eric Rideal on general aspects of talysis and on the course of its development from a storical point of view, the large mass of new material s been arranged in four main groups covering espectively the chemistry and physics of solid talysts, homogeneous catalysis, surface chemistry enerally, and miscellaneous catalytic reactions, any of these groups being subdivided into subections While it is difficult in a short review to elect individual papers for special comment, conderable interest is attached in the first of these oups to the contribution by R E Cunningham and T Gwathmey on the relative rates of hydrogenaon of ethylene on the various crystal planes which e exposed as outcrops on the surface of a spherical ngle nickel crystal The relative rates observed uld not be explained in terms of the ease of geometrical accommodation, without undue strain, of the ethylene molecule , and it is probable that bulk dislocations, which begin within the catalyst, lead to unusual interatomic distances in the surface lattice Prof J H de Boer amplifies this point by discussing the part played by pore structure in providing sites for reaction within the gross external surface of supported and other catalysts

In a further introductory address, Prof W E. Garner gives a good account of the present state of work on reactions involving electron transfer on and in mixed-oxide catalysts, including semiconductors , and this is supplemented by a number of further papers in this field, including one by Prof G M. Schwab in which the effect of illumination on electron-transfer processes between the surface of semiconductors and catalysable substrates is discussed. Reaction paths and energy barriers in homogeneous catalytic systems have been dealt with by Prof D D. Eley, who also includes processes catalysed by enzymes Later sub-sections contain a large number of papers on the relation of surface chemistry to catalysis, the catalytic reactions of hydrocarbons (which is introduced by Dr E J Houdry), tracer techniques, with an introduction by Prof P H. Emmett, and miscellaneous catalytic reactions The subsequent discussions to all the papers are printed in full

E B Maxted

INTRODUCTORY ELECTRONICS

Principles of Electronics

By Prof M R Gavin and Dr J E Houldin (Physical Science Texts) Pp xii + 348 (London English Universities Press, Ltd , 1959) 30s net

THE trouble with this book is that it is not really clear for whom it is written The general editor's foreword states that each volume in the series "is designed to give the reader an integrated account of a subject up to the level of an Honours Degree of any British or Commonwealth University" But the authors claim that it is only a general introduction to the subject of electronics or, as shown on the dust cover, "an introductory course for a first degree or diploma in physics or electrical engineering" , then they go on to claim that, for most of the book, the standard of mathematics required is no more than that of the Advanced Level of the General Certificate of Education Whatever the intentions, there is little doubt that the book is very suitable for the early years of an electrical engineering course but will scarcely cover the requirements of the final stages of an honours course in electrical engineering

Within the restrictions mentioned above, the book is a good one Its descriptions are extraordinarily lucid and straightforward—almost anyone could understand them , and the book might be useful even to technicians It is a book one can enjoy reading , the subject-matter is well selected and strikes a pleasant balance between thermionic valves on one hand and transistors on the other , between physics on one hand and circuits on the other. The coverage of the subject-matter is wide, including the basic electron physics (nearly 100 pages), amplifiers (about 90 pages), oscillators (sinusoidal and relaxation), very-high-frequency valves, rectification, modulation and detection, wave-shaping, and noise It is not surprising that the authors do not find room for communication and control systems or for any study of passive circuits The book is not at any stage abstruse, and unimportant and irrelevant matter seems absent A very valuable feature is the inclusion of about 250 examination-type problems The production is very attractive and the price is reasonable

Not only can the book be recommended as an introductory text for electrical engineering students, but it may also prove useful to many fully fledged engineers and physicists who wish to get up to date on the proper relationship of thermionic and transistor circuits It compares favourably with other recent books on this subject

One or two faults in the book should be mentioned The reviewer did not take kindly to the split infinitives on p 28—"to just ionise" and "to just excite"—nor to the spelling "alinement" on p 37 There is an error in the analysis of a circuit on p 242 (and another similar one on pp 251–2) where the authors neglect the existence of the voltage across the load of a diode D G TUCKER

HISTOLOGY

Textbook of Comparative Histology

By Dr Warren Andrew Pp xix+652 (London and New York Oxford University Press, 1959) 120*s* net

Histochemical Technique

By Dr W G Bruce Casselman (Methuen's Monographs on Biological Subjects) Pp 205 (London Methuen and Co , Ltd , New York John Wiley and Sons, Inc , 1959) 18*s* net

A SURVEY of the histology of both invertebrates and vertebrates in a single volume is indeed a formidable task, and even partial success must rank as a considerable achievement Certainly a cursory examination of Andrew's book does throw its deficiencies into some relief, and more continuous reading is required to reveal its virtues The temptation of saying too little about too much is not entirely avoided and rather many topics are treated too briefly to be easily intelligible, nor is the difficulty overcome of being reasonably up to date, for references from the last decade are somewhat infrequent The chapter bibliographies are unduly short, for the excretory organs of all invertebrates there are thirteen titles ending at 1940, and in general they refer mainly to American and older German work , there is little attempt either to include all the great classical papers or to present a scheme for further reading The coverage of the subject is often correspondingly restricted and there are some disappointing omissions Nevertheless the advanced undergraduate audience for whom the book is primarily intended will find in it much pleasant ancillary reading, arranged in a manner which should stimulate their further interest The broad comparative and essentially functional approach emphasizes the general similarities of the problems facing all animals, and brings out underlying analogies in their solutions The illustrations are numerous and well chosen and the writer's style agreeable, so that such a volume might well lead a student towards one of the most attractive entries into the practice of zoology

The scope and precision of classical histology have been rapidly extended in recent years by the increasing use of physical and chemical methods, and any further assistance in their technical application is welcome Casselman opens with some interesting chapters on the general methods, potentialities and limitations of microscopical histochemistry, followed by succinct accounts of the main groups of substance studied by these techniques The chapter on lipid and their separation, at least to the degree of separation so far feasible, is particularly helpful, but tha on proteins does seem to under-estimate some of th technical difficulties involved The point of viev throughout is chemical and the book can be recommended to biologists primarily as a very useful addition to the other texts now available T KERR

GENETIC ANALYSIS

Trends in Genetic Analysis

By Prof G Pontecorvo (Columbia Biologica Series, No 18) Pp x+145 (New York Columbi University Press , London Oxford Universit Press, 1959) 25*s* net

THE past fifteen years have seen a revolution i genetics comparable to the introduction int physics of quantum theory Several lines of researc have contributed to this revolution The study c biochemical genetics established the concept of 'on gene, one enzyme' The analysis of transformatio and transduction in bacteria showed that hereditar information is carried by nucleic acid These tw conclusions made clear the need to analyse the structure of nucleic acids, to relate this structure to th processes of replication and of protein synthesis, an to seek for the kinds of changes in proteins whic result from genetic mutation But most important c all has been the increase in what Prof Pontecorv has called the "resolving power" of genetic analysi This has caused the abandonment of the old pictur of chromosomes consisting of a series of hereditar units or genes connected by regions at which, an only at which, recombination can take place, and th recognition that genes themselves have a linear structure resolvable by crossing over

Prof Pontecorvo's book is mainly concerned wit this last field of research, although conclusions fro other fields are mentioned where they are relevan The six chapters deal with genetic analysis and i resolving power, allelism, the structure and functio of the genetic material, recombination, mappin chromosomes via mitotic recombination and nov genetic systems

This is an exciting book, partly for the logic an clarity with which new ideas are presented, and partl because the problems which it raises are as fascina ing as the ones which it answers Prof Pontecorv has himself made a decisive contribution to the stud of the fine structure of genes by his recognition an subsequent demonstration that the phenomenon c "position pseudo-allelism" described by E B Lew is not a genetic anomaly, comparable, for exampl to the Notch deficiency in *Drosophila*, but is a typic effect, to be expected if the genetic material is line in its fine structure as well as in its gross morpholog and if its proper functioning depends on the integri of functional units, which Benzer has since pe suaded us to call cistrons For the general biologi who wants to know how this idea has been develope and how it has been combined with discoveries other fields to give a coherent picture of what gen are and what they do, this book is an admirab although sometimes a difficult guide

But the book is mainly intended for geneticist and it seems unlikely that many will be so unwise to leave it unread For them, Prof Pontecorvo greatest virtue is his gift for throwing into relief wh ve do not know The search is already on for the eneticist's Rosetta Stone, that is, for a protein hich can be analysed in the same detail as hæmolobin, determined by a gene the fine structure of hich can be resolved in the same detail as Benzer has esolved the *rII* locus in phage *T*4 But there are ther problems to which no answer is at present in ight One is the relationship between the structure f deoxyribonucleic acid, and the processes of hromosome replication and recombination , it is ot clear at present whether replication and recomination are separate processes or different aspects of he same event A still more fundamental difficulty s the relationship between gene action and morphoenesis If the revolution in genetics achieves its resent objectives, we shall know how a fertilized gg receives the instructions which tell it how to ake a large number of specific proteins , but there s a big difference between a bag of proteins and an nimal or plant J MAYNARD SMITH

NEW APPROACH TO IMMUNITY

he Clonal Selection Theory of Acquired Immunity

y Sir Macfarlane Burnet (The Abraham Flexner
ectures of Vanderbilt University, 1958) Pp
x+209 (Cambridge At the University Press ,
ashville, Tennessee Vanderbilt University Press,
959) 22*s* 6*d* net

THE basic problem of immunology is to understand how the body responds by making antibodies gainst foreign macromolecules, while refraining from aking antibodies against the great variety of macroolecules which are present in its own tissues No atisfactory instructive theory has been yet put orward to explain how the presence of the antigen auses cells to synthesize antibody molecules with a omplementary surface structure In the Abraham lexner Lectures given at Vanderbilt University for 958, and published in this book, Sir Macfarlane urnet has approached the problem at quite a ifferent angle He postulates that individual esenchymal cells are genetically endowed with the otentiality for making globulin capable of combining ith a particular antigenic configuration In the dult organism, contact of the mesenchymal cell with e right antigen causes that cell to proliferate and o differentiate, so as to produce a clone of cells aking, or capable of making, antibody which ombines with the antigen The mesenchymal cells re regarded as being subject to a high rate of somatic utation, so that, when a clone proliferates, some embers will produce globulin better adapted to the ntigen, and these cells in turn will be stimulated electively to proliferate, and so on In this way, ore and more cells will produce antibody capable f combining with more of, or more firmly with, the ntigen surface The problem of antibody production n response to an antigenic stimulus becomes thereore a problem in cell population dynamics, and the ften amazing specificity of antibody for the antigen achieved by a selective, rather than by an instrucve, process To account for the phenomenon of nmunological tolerance, and the failure of antibodies o be formed against molecules present in the organm at birth, Burnet suggests that, during the stage f immunological immaturity, contact of antigen ith cells potentially capable of making antibody gainst it results not in stimulation but in deletion f those clones Hence the adult animal possesses cells capable only of being stimulated by molecules with surface configurations not shared by its own components All other clones become forbidden

If this ingenious theory is correct—in essence, even if not in detail—a fairly ready explanation is available not only for many of the cardinal features of immune responses, such as the difference between primary and secondary, or immunological memory and anamnestic reactions, but also for the development of auto-antibodies According to the clonal solution hypothesis auto-antibodies could be evoked by body constituents which were screened from mesenchymal cells during the stage of immunological immaturity (for example, lens protein, or thyroglobulin), or which only developed later (for example, spermatozoa) They might also arise by somatic mutation in adult life of clones of cells capable of responding to forbidden patterns, such as to nucleic acid Burnet makes the good point that antibodies are normally never formed against even heterologous deoxyribonucleic acid, but that when for some unknown reason they do appear, in persons with disseminated lupus erythematosus, they react with deoxyribonucleic acid from all sources including the nuclei of the sufferer's own cells On the basis of his theory clones capable of making antibody against any deoxyribonucleic acid are forbidden, and eliminated, for the very reason that when antibody *is* formed, as a rare result of a somatic mutation, it will be an auto-antibody

This example illustrates the self-consistency and the attractiveness of the theory It is important to remember, however, that there is very little direct evidence to support its main assumption that clones of mesenchymal cells have a built-in response to a particular antigenic pattern, or to explain their deletion during embryonic life and stimulation later The subsidiary hypothesis that lymphocytes, macrophages, plasma cells and primitive reticulum cells are all interconvertible is one the truth of which is convenient rather than proved, and so is the assumption that mesenchymal cells are hypermutable as regards somatic mutations Biochemically minded readers may be disappointed by the frank rejection of a biochemical approach, and by the relegation to chance variations in a basic globulin structure of the problem of how antibody is synthesized with a pattern complementary to the antigen Some may even be stimulated to try to show that a single cell can produce two or more unrelated antibodies at the same time—a finding which would be difficult to accommodate into the theory, and on which the evidence is at present conflicting

The later chapters set out to show how the theory would apply to a wide range of phenomena from collagen disease to cancer, and to some of the latest experimental findings in immunology Burnet manages with elegance in some cases, ingenuity in others, and occasionally a good deal of stretching to accommodate them all—including at least two experimental findings which have since become highly suspect or been withdrawn This last is mentioned no more than as a warning that Sir Macfarlane has such enthusiasm and confidence in his latest ideas, that he can sweep up everything, including the readers, in his path The ideas are, in any event, original and stimulating and have been carried further than anyone has tried to carry any of the alternative hypotheses It is likely that a good deal of future work will be influenced by them, for their author has a reputation of having hit the right nail on the head on notable occasions in the past J H HUMPHREY

Statistics of Extremes

By Prof E J Gumbel Pp xx+375 (New York Columbia University Press, London Oxford University Press, 1958) 120*s* net

THE theory of extreme values is concerned with the probability distribution of the largest values encountered in samples of finite size it has many applications including the occurrence of floods and droughts and the breakdown of materials, such as aircraft components, subject to varying stresses and strains

Prof Gumbel has for many years been a leading authority on the subject and his book is likely to become a standard work Although the book appears to contain little essentially new theory, it collects and elaborates previous work hitherto widely scattered in the statistical literature and contains many tables and graphs of functions occurring in the theory There is an excellent bibliography containing references to both theoretical and applied work The text includes numerous exercises for the reader The eight chapter headings are "Aims and Tools", "Order Statistics and Their Exceedances", "Exact Distribution of Extremes", "Analytical Study of Extremes", "The First Asymptotic Distribution", "Uses of the First Asymptote", "The Second and Third Asymptotes" and "The Range"

Although several examples of applications are discussed, this book is not a 'cook-book' of practical methods, but it should prove extremely useful to the statistician required to analyse extreme-value data The scientist interested in practical applications will need considerable mathematical and statistical experience to follow the rather concentrated and sophisticated mathematics In particular he may find difficulty in assessing the practical importance of some of the concepts defined and some of the results derived

The high cost probably makes this book one for the library rather than for the individual and is presumably due to the large number of graphs it contains

R N Curnow

The Chemistry of Natural Products

Vol 1 The Alkaloids By K W Bentley Pp vii+237 4 dollars Vol. 2 Mono- and Sesquiterpenoids By P de Mayo Pp vii+320 52*s* Vol 3 The Higher Terpenoids By P de Mayo Pp vii+239 42*s* (New York Interscience Publishers, Inc , London Interscience Publishers, Ltd , 1959)

BOOKS on natural products have in the past usually suffered from several disadvantages they have tended to consist of catalogues, and quite frequently have been written by specialists who had rather lost contact with the general body of advancing science and did not emphasize relations to chemistry in general A very welcome tendency is for young and enthusiastic men, themselves deeply involved in the subject from the research side, to summarize fields of research in what might be described as super Ph D theses The advantage of their approach is that it is fresh, but nevertheless authoritative, and that their acquaintance with modern theories of reaction mechanisms and biosynthetic theories enables them to produce monographs which are of general interest and general importance The three books in the title are in this class They should interest and inform advanced undergraduates, research students and university or college teachers who have not had the time to keep up with the literature They are not perhaps exhaustive enough for research specialist but should provide useful starting-points for research The general resemblance to theses, particularly i the formulae, will not please lovers of beautifu books, but presumably they would otherwise hav been more expensive They can be heartily recommended to all who are interested in rapidly advancin fields whether as teachers, students or researc workers

A J Birch

The Psychology of Social Class

By Maurice Halbwachs Translated by Claire Delavenay (Heinemann Books on Sociology) Pp xvii+142 (London William Heinemann, Ltd 1958) 16*s* net

MAURICE HALBWACHS was a French sociologist who learnt in his early manhood to shar the liberalism and democratic principles whic deeply influenced the generation destroyed by th First World War It was his inheritance of thes principles which led to his own death in Buchenwal in 1945, and it is for this that he must be remembere and honoured His work as a sociologist is typical o a transitional age, and his writings on the sociolog of class distinctions and behaviour are of interest i so far as they illustrate the swing-over from the over systematic thinking of the sociologists of the nineteenth century to the empiricism which appears t be gaining ground in the second half of the twentieth

It is evident, however, that Halbwachs had no shaken off his attachment to abstract theories eve as late as 1938, when he wrote this book ; moreove it is also evident that he had not mastered the difficulties of basing generalizations on evidence in suc a way that a framework of truly scientific theor might be constructed On one hand, Halbwach was unable to resist the temptation to quote from th works of the great classical philosophers, as well a the theorists of his own age, such as Durkheim an Weber On the other, he was only too ready to present a mass of often undigested information derive from such sources as the German Government' survey of working-class budgets, carried out i 1927–28 What was lacking in his work was a seriou attempt to relate the evidence to the generalization founded on it

T S Simey

Toward a Systematic Pragmatics

By R M Martin (Studies in Logic and the Foundations of Mathematics) Pp xv+107 (Amsterdam North-Holland Publishing Company, 1959) 24*s*

THIS recent addition to "Studies and Foundations" is a valuable monograph in a highl specialist field, and adds lustre to that distinguishe series The main discussion concerns type-theoretica systems, pragmatical meta-language, analytic trut and absolute intensions These subjects are introduced by a preliminary chapter on the nature o pragmatics In brief, language-systems can be eithe syntactical, semantical or pragmatical, and this corresponds to the order of abstraction

Thus, in syntax, it is only the signs or expression (and their inter-relations) which are interesting I semantics, the objects which the signs denote com into the picture Finally, in pragmatics, the speaker or users of the language are involved The author' point of view is wholly extensional, whereas that o Carnap is intensional The power of extensiona meta-languages to cover a large part of mathematics physics, and even biology, is clearly advantageous

F I G Rawlins

STRONTIUM-90 IN THE AUSTRALIAN ENVIRONMENT, 1957—58

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Introduction

DURING the past four or five years a considerable effort has been made, notably in the United States and the United Kingdom, to gain precise information on the world-wide distribution of radioactive fallout from nuclear weapon tests. Results of such measurements to about mid-1957 were included in the extensive review of the subject prepared by the U.N. Scientific Committee in August 1958[1]. Further results for 1957 and also for 1958 for the United States, the United Kingdom and other areas have since been published, notably by Bryant *et al.*[2-4], Stewart *et al.*[5] and the U.S. Atomic Energy Commission Health and Safety Laboratory[6-9].

In April 1957 the programme of fallout measurements, initiated by the Australian Atomic Weapons Tests Safety Committee[10-15] to cover local weapon tests and to monitor global fallout, was extended to include the determination of strontium-90 in representative Australian materials. Arrangements were made for the sampling of soil, powdered milk, cabbages and human and sheep bone tissue. All samples were sent to the United Kingdom for radiochemical analysis by the Atomic Energy Research Establishment Group at Woolwich Arsenal, under the direction of one of the authors (F. J. B.). In this report results are presented for the early part of the programme extending from May 1957 to September 1958, during which period 243 samples were processed. In order to minimize the radiochemical effort, a number of the bone samples were bulked and the actual chemical analyses were reduced in this way to 148.

Sampling Programme

It is well known that strontium-90 in global fallout enters the human body mainly as a contaminant of dietary materials; the uptake through inhalation is very small by comparison[16]. Therefore, the sampling programme was designed to monitor levels of strontium-90 in materials which are representative of the phases between deposition of strontium-90 on the ground and its absorption into human bone. The primary material of the programme was human bone tissue. Because milk products, generally, are a major contributor of calcium and strontium-90 to the Australian diet, milk was chosen as the important representative dietary material and, for convenience, samples of powdered milk were taken for analysis; however, cabbages were included to monitor the contribution to the diet made by leaf crops. Soil and yearling sheep bone tissue were assayed to provide information on the accumulation and rate of deposition of strontium-90 at ground-level; measurements were also made on total precipitation collected in stainless steel pots during the latter half of 1958.

The materials selected, and the sampling procedures adopted, were not expected to allow a complete examination of the uptake processes. This can most satisfactorily be done by controlled experimentation within a laboratory, of the type carried out by Russell and his Agricultural Research Council group[17-19].

Samples of human bone tissue, powdered milk, cabbages and soil were taken from the Perth, Adelaide, Melbourne, Sydney and Brisbane areas during 1957 and 1958, while sheep bones were

Table 1*a* STRONTIUM-90 IN AUSTRALIAN HUMAN BONE SAMPLES* DECEMBER 1957–SEPTEMBER 1958 UNDER 5 YEARS

Locality	Bone	Age*	Strontium-90 (μμc./gm. calcium)	
			Analytical result	Mean
Perth	Femora	Stillborn	0.3	0.57
	,,	,, and 3 m.	0.3	
	Femur	4 m.	0.3	
	,,	9 m.	1.0	
	,,	16 m.	1.3	
	Vertebræ	3½ y.	0.5	
Adelaide	Femur	1 d.	0.5	0.53
	Femora	1 d. and 3 d.	0.2	
	,,	19 d. and 24 d.	0.4	
	,,	1 m. and 3 m.	0.3	
	Femur	3 m.	0.35	
	,,	4 m. and 6 m.	0.7	
	,,	7 m.	1.5	
	,,	7 m.	0.6	
	,,	13 m.	0.7	
Melbourne	Vertebræ	2 d., 7 d., 21 d. and 2 m.	0.35	0.59
	,,	6 m. and 10 m.	0.5	
	Crania	23 m. and 24 m.	0.85	
	,,	30 m.	1.4	
	,,	3½ y.	0.4	
Sydney	Femora	9 d. and 16 d.	0.3	0.64
	Femur	3 m.	0.5	
	Femora	6 m., 6 m., 7 m. and 7 m.	0.75	
	Femur	11 m.	0.5	
	Femora	22 m., 23 m. and 24 m.	0.65	
	Femur	30 m.	1.0	
	Vertebræ	Stillborn and 11 m.	0.7	
Brisbane	Vertebræ	1 m. and 7 m.	1.0	0.70
	,,	18 m.	0.45	
	,,	24 m. and 28 m.	0.7	
	,,	28 m.	0.4	
	,,	3 y.	0.75	
	,,	5 y.	0.6	
Total	52 samples			(0.60±0.10)

* The age distribution of the specimens is shown in Fig. 1.

Table 1*b* STRONTIUM-90 IN AUSTRALIAN HUMAN BONE SAMPLES* DECEMBER 1957–SEPTEMBER 1958
ALL AGES

Locality	Under 5 years				5 years–20 years				Over 20 years				
	Bone	No of samples	No of analyses	Mean strontium-90 $\mu\mu c$ /gm calcium	Bone	No of samples	No of analyses	Mean strontium-90 $\mu\mu c$ /gm calcium	Bone	No of samples	No of analyses	Strontium-90 $\mu\mu c$ /gm calcium	
												Mean	Normalized†
Perth	Vertebræ Femora	1 6	1 5	0 57	Vertebræ Femur	3 1	1 1	0 30	Vertebræ	11	1	0 2	0 11
Adelaide	Femora	13	9	0 53	Femur	1	1	0 3	Femora	16	1	0 04	0 08
Melbourne	Vertebræ Crania	6 4	2 3	0 59	Vertebræ Crania	2 8	1 1	0 36	Vertebræ	12	1	0 3	0 17
Sydney	Vertebræ Femora	2 12	1 6	0 64	Vertebræ Femora	1 6	1 1	0 33	Vertebræ	18	1	0 2	0 11
Brisbane	Vertebræ	8	6	0 70	Vertebræ Ribs	2 1	1 1	0 30	Vertebræ	8	1	0 25	0 14
Total		52	33	0 60 ±0 10		25	9	0 33 ±0 05		65	5		0 12 ±0 02

* The age distribution of the specimens is shown in Fig 1
† Normalization of the analytical results of the adult tissue has been performed using the factors of Schulert *et al* (ref 22)

Table 1*c* STRONTIUM-90 IN AUSTRALIAN HUMAN BONE SAMPLES*
DECEMBER 1957–SEPTEMBER 1958
ALL AGES AND LOCALITIES

Age group	Femora		Vertebræ		Crania		Ribs	
	$\mu\mu c$ /gm calcium	Mean age	$\mu\mu c$ /gm calcium	Mean age	$\mu\mu c$ /gm calcium	Mean age	$\mu\mu c$ /gm calcium	Mean age
Under 24 months	0 54 (30, 19)†	6 m	0 57 (11, 5)†	6 m	0 85 (2, 1)†	23 m	—	—
24–59 months	1 0 (1, 1)	30 m	0 61 (6, 5)	36 m	0 9 (2, 2)	33 m	–	—
5–20 years	0 34 (8, 3)	8 y	0 31 (8, 4)	12 y	0 35 (8, 1)	7 y	0 3 (1, 1)†	14 y
Over 20 years	0 04 (16, 1)	66 y	0 23 (49, 4)	57 y	—	—	—	—

* The age distribution of the specimens is shown in Fig 1
† Number of samples , number of analyses

supplied from 23 localities throughout Australia during the same period , these materials were taken from sites across the continent within a range of latitudes of 20°–38° S The analytical methods used for the determination of strontium-90 were those described by Bryant *et al* [2,3 16,20]

Sampling Methods and Results

The results are given in Tables 1–5 and wherever possible mean values and the corresponding errors have been derived to facilitate comparisons with the results of similar surveys conducted elsewhere

(*a*) *Human Bone Tissue* Between December 1957 and September 1958 pathologists in the five capital cities supplied a total of 142 specimens of human bone tissue For each area the specimens were divided into three age-groups, namely, under 5 years, 5–20 years and over 20 years In the latter two groups some bulking of material was employed to reduce the number of analyses, while the majority of the infant specimens were analysed individually In all, 47 analyses were performed

It was impracticable to restrict the survey to a single type of bone, and samples of vertebræ, femora and crania were accepted , when adult femora were supplied only the shafts were analysed, but whole bones were included for the younger specimens Each specimen comprised at least 20 gm of wet bone

For each age-group and area the various bone types were not mixed in the bulking of material prior to analysis Information could, therefore, be obtained on any variations of strontium-90 concentration among the bone types employed Because the proportion of calcium in bone ash is approximately constant[21], the bulking of specimens was performed on the basis of equal masses of ash

The final stage of the radiochemical analysis took one of two courses depending on the activity of the

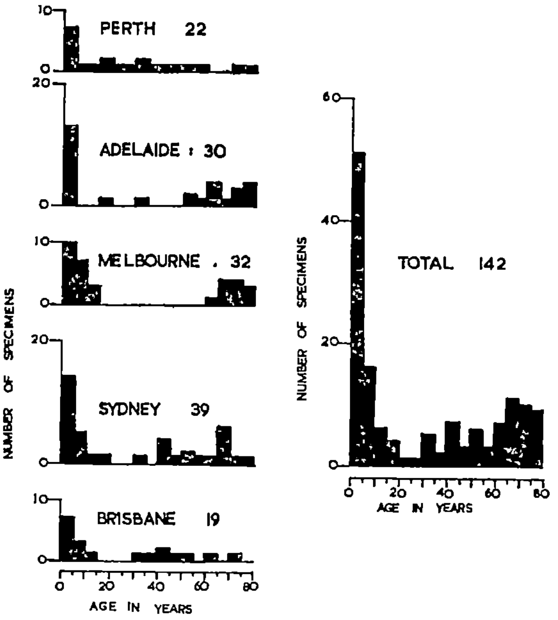

Fig 1 Age distribution of the human bone specimens

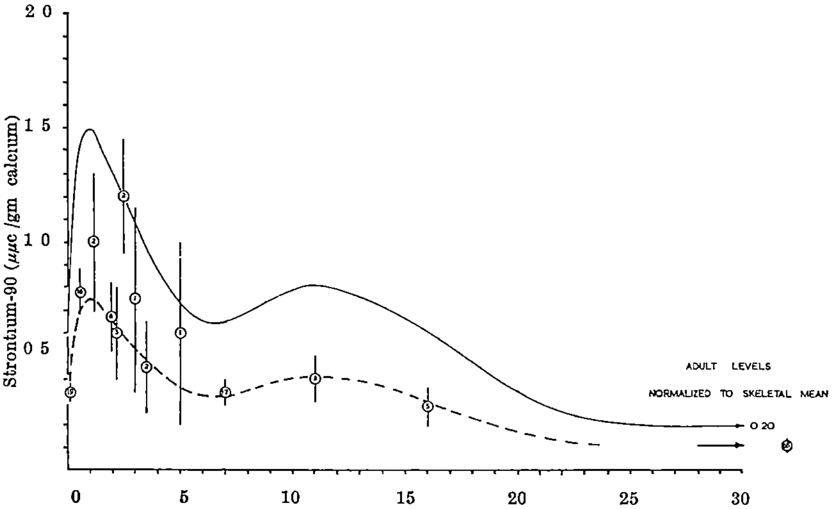

Fig 2 Variation with age of strontium-90 concentration in human bone tissue O, Australia, May 1958 , ——, North America and Europe, January 1958 (ref 23), – – –, 0 5 (North America and Europe, January 1958)

extracted strontium isotopes, strontium-89 and -90 Where possible yttrium-90 was separated for counting after equilibration with mother strontium-90 , on the other hand, for low activities the unwanted strontium-89 was allowed to decay for about two half-lives and the strontium-90 content estimated Both methods gave consistent results

Fig 1 shows the age distribution of the specimens collected, from which it will be seen that the unequal availability of material, particularly in the middle years, has led to emphasis on very young and old tissue The complete data are recorded in Tables 1*a*, *b* and *c* and the distribution of strontium-90 concentration with age is exhibited in Fig 2 The mean values derived in the tables, and also those plotted in Fig 2, are considered to refer to strontium-90-levels in human bone at May 1958

Table 1*c* shows that there is no evidence for a bone variation in age-groups up to 20 years , however, for older tissue, vertebræ have a considerably higher contamination than femora, as reported by the Lamont Group[22–24], from more extensive measurements The results for adults, therefore, have been normalized to the skeletal mean using the factors derived by Schulert *et al* [22]

No significant variations of strontium-90 in human bone were observed between the five capital cities, and so the five groups of data were combined to give the mean strontium-90 concentrations in age-groups, plotted in Fig 2 The estimated standard deviations and the number of specimens on which the mean values were based are also shown A distribution of strontium-90 concentration with age, computed by Kulp *et al* [23], gives a good description of their North American and European bone tissue data of January 1958 This distribution is shown as the full curve in Fig 2, while, as the broken curve, it has been scaled down by 2 to facilitate comparison with Australian data of May 1958

Table 2 STRONTIUM-90 IN AUSTRALIAN POWDERED MILK SAMPLES*

Grazing locality of cattle	August 1957	March 1958	Rainfall August 1957–March 1958 (in)	August 1958	Rainfall March 1958–August 1958 (in)
	Strontium-90 μμc /gm calcium	Strontium-90 μμc /gm calcium		Strontium-90 μμc /gm calcium	
Brunswick Junction 90 miles south of Perth	2 9	1 8	5 0	4 9	29 0
Mt Compass 30 miles south of Adelaide	4 2	3 8†	6 6‡	7 7	23 3‡
Maffra 110 miles east of Melbourne	4 0	2 7	15 1	4 4	7 9
Lower Hunter River Valley 90 miles north of Sydney	2 4	1 6	14 0	1 8	8 9
Mary River Valley 100 miles north of Brisbane	5 3	2 2	23 7	6 1	24 2
Mean	3 8 ±1 0	(2 4 ±0 8)		(5 0 ±1 6)	

* Each sample was at least 1 5 kgm † Taken in January 1958
‡ Rainfall periods taken to and from January 1958

(*b*) *Milk* The powdered milk samples were taken from factories supplying the five capital cities in August 1957 and March and August 1958 In each case the milk was of known age and origin and the later samples were taken from cattle grazing in the same locality, although not necessarily the same pasture All but a few samples were full-cream powdered milk

The analytical results are given in Table 2 and show the March 1958 levels to be lower than those for August 1957 and 1958, suggesting a seasonal variation of the type noted by other authors, for example, Stewart *et al* [5,25]

(*c*) *Cabbages* During August 1957 and 1958, two or three cabbages grown within the vicinity of each of the five capital cities were ashed for analysis without prior washing or other preparation Before the determination of both calcium and strontium-90 contents the ash from each sample was decomposed with a mixture of HF and $HClO_4$ in the presence of strontium and barium carriers The analytical results are presented in Table 3

(*d*) *Sheep Bone Tissue* This material was included in the programme because the strontium-90 accumulation in the bones of yearling sheep can be used as a monitor of fallout deposition Moreover, through their habit of grazing extensively, sheep

Table 3 STRONTIUM-90 IN AUSTRALIAN CABBAGES

Locality	August 1957		August 1958	
	Calcium in ash (per cent)	Strontium-90 μμc /gm calcium	Calcium in ash (per cent)	Strontium-90 μμc /gm calcium
Perth	8 9	4 0	12 2	4 0
Adelaide	6 9	2 3	11 1	4 3
Melbourne	7 7	2 1	6 0	9 4
Sydney	7 9	2 1	13 0	4 1
Brisbane	6 8	2 6	11 8	7 7
Mean		(2 6±0 7)		(5 9±1 8)

tend to integrate out local variations in fallout deposition, and sheep bone tissue is available in areas of Australia where other representative samples are difficult to obtain.

The first collection of sheep bones was made from 13 widely separated areas during May–June 1957, and further collections were made from 16 areas in August 1957 and 1958. The grazing localities are shown in Fig. 3. In each case representative long bones were selected from the legs of up to three sheep each of which had grazed over natural grasses throughout most of its life.

In all, 59 analyses were performed on material collected from 89 sheep during the three surveys and

Table 4. STRONTIUM-90 IN AUSTRALIAN SHEEP BONE SAMPLES

Locality	May–June 1957			August–September 1957			August 1958		
	No. of sheep	Approximate age (months)	Strontium-90 μμc./gm. calcium	No. of sheep	Approximate age (months)	Strontium-90 μμc./gm. calcium	No. of sheep	Approximate age (months)	Strontium-90 μμc./gm. calcium
Beverley 70 miles E. Perth	3	8	5.3	1	12	7.0	3	13	6.4
Salisbury 20 miles N. Adelaide	2	8	21*	1 1 1	15 15 15	7.5 9.1 9.5	3	14	8.8
Quorn 180 miles N. Adelaide				1 1 1	15 15 13	10.2 7.6 11	3	15	16
Marree 360 miles N. Adelaide	1	8	3.0	1 1	14 14	2.1 1.9	1	12	3.7
Ingomar 430 miles N.N.W. Adelaide	3 —	12 12	5.7 5.4						
Coober Pedy 470 miles N.N.W. Adelaide				1 1 1	15 15 15	5.5 7.7 8.0	3	15	4.7
Mabel Creek 480 miles N.N.W. Adelaide	2 —	12 12	6.5 7.3						
Evelyn Downs 530 miles N.N.W. Adelaide				1 1	14 14	7.0 6.3			3.8
Mt. Willoughby 550 miles N.N.W. Adelaide	2 —	10 12	10 11						
Victory Downs 700 miles N.N.W. Adelaide				2	16	4.6	3	12	4.2
Yarra Valley 30 miles E. Melbourne	2 1	8 8	13 14						
Yarrawonga 140 miles N.N.E. Melbourne				1	13	12	3	13	7.9
Sydney	1	9	12	1	13	8.2	2	11	6.9
Canberra	1	8	7.3						
Dubho 180 miles N.W. Sydney				1	11	4.6	2	13	3.8
Bourke 400 miles N.W. Sydney	1 1	9 8	3.8 2.7						
Lismore 370 miles N.N.E. Sydney	1	8	5.8						
Brisbane	3	8	1.5	1	12	1.6	1	14	1.2
Southport 50 miles S.S.E. Brisbane				1 1	11 11	8.1 9.2	2	12	6.3
Rockhampton 320 miles N.N.W. Brisbane				1	11	5.3	1	13	4.6
Charleville 430 miles W. Brisbane	1	9	8.0	1	12	7.2	2	12	5.3
Townsville 680 miles N.W. Brisbane				1	11	6.1	2	12	3.9
Cloncurry 900 miles W.N.W. Brisbane				1	12	1.0	3	16	1.5
Mean Total No. of analyses	25	18	(7.9±2.2)	26	25	(6.6±1.5)	34	16	(6.3±1.5)

* The sheep from which this bone tissue was taken grazed in the Mt. Compass area.

Table 5 STRONTIUM-90 IN AUSTRALIAN SOIL SAMPLES*

Locality	August 1957				August 1958				Rainfall August 1957–August 1958 (in)
	Sample area (m ^{2})	Calcium gm /kgm	Soil surface density kgm /m ^{2}	Strontium-90 mc /km ^{2}	Sample area (m ^{2})	Calcium gm /kgm	Soil surface density kgm /m ^{2}	Strontium-90 mc /km ^{2}	
Perth	0 041	0 6	134	2 7	0 041	0 8	90	3 5	30
Adelaide	0 041	3 0	29	1 6	0 041	1 8	61	2 0	17
Melbourne	0 041	2 7	105	3 4	0 039	1 6	76	2 2	24
Sydney	0 039	2 3	80	2 5	0 049	2 3	88	3 7	54
Brisbane	c 0 04	1 0	96	2	0 041	0 6	41	1 0	35
Mean				(2 4±0 4)				(2 5±0 7)	

* Top 10-cm soil plus surface matt

the results are shown in Table 4 Results which are systematically low for all three surveys are apparent for some areas These low values may be associated with variations in rainfall, soil and grazing conditions

However, Table 4 also shows that the mean strontium-90-level in yearling sheep bone is virtually constant for the three successive surveys This implies that the strontium-90-levels in sheep bone tissue of this age depend mainly on the rate of deposition of fallout, lending support to Russell's[26] recent suggestions concerning the relative roles of total fallout and the fallout rate in the take-up of strontium-90 into plants

Apart from the systematic variations at particular locations referred to above, the skeletons of yearling sheep throughout Australia appear to be contaminated with strontium-90 to approximately the same extent Fallout is therefore uniform across the continent, the slight latitudinal variation suggested by other measurements[27] is not reflected in these results

(*e*) *Soil* During August 1957 and 1958, samples of soil to a depth of 10 cm were taken from uncultivated land within each of the five capital cities At each site succeeding samples came from the same immediate vicinity but the sites themselves were associated with neither milk production nor market gardening The surface dimensions of the samples lay between 0 04 and 0 05 m ^{2}, the surface matt was analysed with the soil

The 10 samples were treated using the hydrochloric acid leaching method, which is considered to give complete extraction of both calcium and strontium-90 The analytical results shown in Table 5 would imply that within the errors there has been no overall accumulation of strontium-90 in Australian soils during the period of the investigation This conclusion is unacceptable because measurements of total precipitation collected in open pots at eight sites in Australia during part of this period, and discussed below, suggest an annual deposition rate of nearly 1 mc /km ^{2} This figure is similar to that reported for Australia by Alexander[27], in the course of a world-wide survey of strontium-90 in soil, his results for 1956 and 1958, for samples taken at six Australian sites, are shown in Table 6

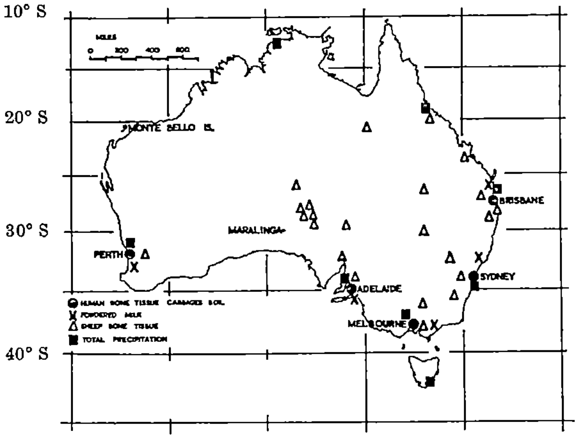

Fig 3 Sampling localities

Table 6 STRONTIUM-90 IN AUSTRALIAN SOIL SAMPLES* (Taken from "Strontium-90 Distribution as determined by the Analysis of Soils" by L T Alexander (ref 27))

Locality	May 1956 (mc /km ^{2})	March 1958 (mc /km ^{2})
Perth	1 0	1 8
Adelaide	2 0	4 5
Hobart	0 5	4 3
Brisbane	1 3	4 5
Alice Springs	0 7	1 2
Katherine	—	1 8
Mean	(1 1 ± 0 4)	(3 0 ± 1 0)

* (1) Top 15-cm soil plus surface matt, (2) two samples of 0 126 m ^{2} were taken on each occasion at each site Results quoted are averages

This conflict between the two sets of results is most probably related to certain characteristics of the soil samples Although the same sites were revisited annually, as Table 5 shows, the samples showed considerable fluctuations of density and calcium content and such factors might account for the low values recorded for the accumulated deposit of strontium-90

Taken at face value the present data lead to a mean level at August 1958 of about 2 5 mc /km ^{2}, somewhat lower than the mean value, 3 0 mc /km ^{2}, of Alexander's data for Australia

(*f*) *Total Precipitation* Commencing in June 1958 stainless-steel pots, 12 in in diameter and 12 in high, were exposed continuously at the eight stations shown in Fig 3 This aspect of the fallout monitoring programme was carried out in co-operation with the U S Atomic Energy Commission, as part of its open-pot sampling effort[6–9]

Both precipitation and solid deposition were collected over monthly periods and in each case the

Table 7 AUSTRALIAN HIGH-WALLED POT SAMPLES JUNE–DECEMBER 1958

Locality	Period	Accumulated strontium-90 (mc /km ^{2})	Estimated annual rate (mc /km ^{2})
Perth	June–November 1958	0 38	0 8
Adelaide	,, ,, ,,	0 74	1 5
Melbourne	,, October ,	0 38	0 9
Hobart	,, ,, ,,	0 68	1 6
Sydney	,, November ,,	0 66	1 3
Brisbane	July ,, ,,	0 64	1 5
Townsville	June ,, ,,	0 3	0 6
Darwin	July ,, ,,	0 86	2 1
			Mean (1 2±0 3)

catch was analysed for strontium-90 by the Health and Safety Laboratory of the U S Atomic Energy Commission, the results are shown in Table 7

Taking into account the seasonal variation in fallout rate the mean annual rate of deposition of strontium-90 for Australia approximates to 1 mc / km^2 Further work, now in progress, will establish this rate more definitely

Comparisons of Australian Strontium-90 Levels with those in the Northern Hemisphere

The nearly uniform fallout of strontium-90 in Australia contrasts with considerable fluctuations observed in the United Kingdom and the United States, where the bulk of northern hemisphere measurements have been made Nevertheless, rough average levels can be compared in those cases where data are available for the appropriate time (the United States does not measure sheep bones or cabbages)

The human bone results given in Fig 2 show that the Australian levels are somewhat less than one-half those for the northern hemisphere In the cases of milk and cabbages, comparisons with American[6-9] and British[4] data again indicate levels which are about one-half the northern hemisphere values while Australian sheep bone results for 1957 indicate levels less than one-half those in the United Kingdom[4] at that time

Australian soil-levels lie between one-fourth and one-third of those of the more densely populated regions of the northern hemisphere[27], while the open-pot measurements indicate a strontium-90 fallout rate of less than one-quarter that operative in the northern hemisphere

Conclusions

(1) Within the sampling errors, and apart from some local variations noted, the levels of strontium-90 in the material examined are uniform throughout Australia This indicates that the strontium-90 fallout over the continent arises from high-yield fission weapon tests overseas. as expected the contribution from local weapon tests is too small to be detected

(2) The rate of deposition of strontium-90 and its accumulation in Australian soils are one-fourth to one-third those in the more densely populated areas of the northern hemisphere The levels of strontium-90 in Australian human bone tissue and milk lie between one-third and one-half those in the northern hemisphere This level is a little higher than would be expected from the fallout rate and the soil data, but the difference is not established statistically If further experiments prove this difference to be real it would be hard to explain satisfactorily

A similar difference between bone and soil-levels was reported by Kulp *et al* [23] for other southern hemisphere samples and they considered that it might be due to the movement into the southern hemisphere of foodstuffs containing strontium-90 produced in the northern hemisphere This explanation is unsatisfactory in the Australian case for the continent is self-sufficient in most primary production, especially of milk and cereals Further results from the Australian survey should elucidate the position

(3) The possible biological consequences to the population of Australia, of the fallout-levels reported in this paper, have been assessed by the Australian National Radiation Advisory Committee[28] The Committee concluded that the possible hazards are very small in comparison with those already accepted in technically advanced communities

[1] U N Scientific Committee on the Effects of Atomic Radiation Report to the General Assembly, 1958 (United Nations, New York, 1958)

[2] Bryant, F J , Henderson, E H , Spicer, G S , Webb, M S W , and Webber, T J , A E R E Report *C/R* 2583 (May 1958)

[3] Bryant, F J , Morgan, A , and Spicer, G S , A E R E Report *HP*/2730 (November 1958)

[4] Bryant, F J , Chamberlain, A C , Spicer, G S , and Webb, M S W , *Brit Med J* , 1371 (1958)

[5] Stewart, N G , Osmond, R G D , Crooks, R N , Fisher, E M R , and Owers, M J , A E R E Report *HP/R* 2790 (January 1959)

[6] U S A E C Health and Safety Laboratory, H A S L 42 (October 1958)

[7] U S A E C Health and Safety Laboratory, H A S L 51 (November 19, 1958)

[8] U S A E C Health and Safety Laboratory, H A S L 55 (February 24, 1959)

[9] U S A E C Health and Safety Laboratory, H A S L 65 (May 29, 1959),

[10] Butement, W A S , Dwyer, L J , Eddy, C E , Martin, L H , and Titterton, E W , *Aust J Sci* , **20**, 125 (1957)

[11] Butement, W A S , Dwyer, L J , Martin, L H , Stevens, D J , and Titterton, E W , *Aust J Sci* , **21**, 63 (1958)

[12] Dwyer, L J , Martin, J H , Stevens, D J , and Titterton, E W , *Aust J Sci* (in the press)

[13] Dwyer, L J , Keam, D W , Stevens, D J , and Titterton, E W , *Aust J Sci* , **20**, 39 (1957)

[14] Keam, D W , Dwyer, L J , Martin, J H , Stevens, D J , and Titterton, E W , *Aust J Sci* , **21**, 8 (1958)

[15] Keam, D W , Dwyer, L J , Martin, J H , and Titterton, E W , *Aust J Sci* (in the press)

[16] Bryant, F J , Chamberlain, A C , Morgan, A , and Spicer, G S , A E R E Report, *HP/R* 2353 (August, 1957)

[17] Russell, R S , and Milbourn, G M *Nature*, **180**, 322 (1957)

[18] Middleton, L J , *Nature*, **181** 1300 (1958)

[19] Milbourn, G M , Ellis, F B , and Russell, R S (in the press)

[20] Bryant, F J , Chamberlain, A C , Morgan, A , and Spicer, G S , A E R E Report, *HP/R* 2056 (September 1956, May 1957 (amend))

[21] Annual Report, Geochemistry Laboratory, Lamont Geological Observatory, Columbia University, N Y (1958)

[22] Schulert, A R , Hodges, E J , Lenhoff, E S , and Kulp, J L , *Health Phys* (in the press)

[23] Kulp, J L , Schulert, A R , and Hodges, E J , *Science*, **129**, 1249 (1959)

[24] Schulert, A R , Peets, E A , Laszlo, D , Spencer, H , Charles, M , and Samachson, J , *Int J App Rad and Isot* , **4**, 143 (1959)

[25] Stewart, N G , Osmond, R G D , Crooks, R N , and Fisher, E M R , A E R E Report *HP/R* 2354 (October 1957)

[26] Russell, R S , *Nature*, **182**, 834 (1958)

[27] Alexander, L T , Statement before the Joint Committee on Atomic Energy, U S Congressional Hearings, May 5-8, 1959

[28] Report to the Prime Minister by the National Radiation Advisory Committee, July 1959

EVOLUTION OF HOST–PARASITE RELATIONSHIPS

PROF JEAN BAER (Neuchâtel) opened a symposium held by Section D (Zoology) at the recent British Association meeting in York on the "Evolution of Host–Parasite Relationships" He began by analysing an ecological survey of such relations The survey was limited to biting and sucking lice, fleas and worms parasitic in vertebrates, because the taxonomy and host-distribution of these parasites have been well studied, their life-cycles are usually complex and diverse and their host-relations show great diversity

The host or host-group is comparable ecologically to an island, the parasites representing the endemic fauna, and the more isolated the island, or the more specialized the host, the higher is the degree of endemicity of its fauna There is a great deal of evidence showing that both morphological and physiological specialization of the parasites is a consequence of their adaptive evolution to distinct groups of hosts

A reliable impression of host-distribution can be derived from histograms of the numbers of genera of parasites in particular host classes, and from the individual distribution of each group may be deduced its probable age

Mallophaga, for example, occur exclusively on birds and mammals, and have evolved more extensively on the former than on the latter Monogenea are parasites on elasmobranchs, teleosts, amphibians and reptiles but are far more widely specialized on teleosts than on elasmobranchs and only very slightly on amphibians and reptiles Cestodes occur throughout all the major groups of vertebrates , the greatest number of genera is found in birds and in elasmobranchs, whereas the largest number of genera of trematodes is found in teleosts even though trematodes have been reported from all the major groups of vertebrates

Host–parasite relationships as expressed by the number of genera of parasites associated with a given group of hosts also imply that the age of the parasites, that is, the time when they first adopted parasitism as a way of life, varies considerably For example, fleas, lice and Mallophaga are unknown from hosts other than birds and mammals and it is extremely unlikely that such parasites existed before their hosts themselves appeared in late Cretaceous times Monogenea and cestodes were already most certainly associated with the precursors of modern sharks and appear to have accompanied the aquatic ancestors of the land-dwelling vertebrates Moreover, ectoparasitic Monogenea have only been able to survive by seeking refuge within the mouth cavity, œsophagus and urinary bladder of their hosts, and since their life-cycle restricts them to an aquatic habitat, they are associated with vertebrates such as amphibians and freshwater tortoises On the other hand, tapeworms living invariably within the gut of their hosts have evolved together with the latter and, as their life-cycles also became adapted to terrestrial intermediate hosts, it is natural that these parasites occur in land-dwelling vertebrates, that is, in reptiles, birds and mammals

These parasites of vertebrates were discussed ecologically, separately as ectoparasites and as endoparasites, and as to whether the larval forms had a free-living stage or not The ectoparasites with no free-living stage were the Mallophaga and the Anopleura, and with a free-living stage, the terrestrial Siphonoptera, and the aquatic Monogenea The endoparasites were those with a gradual metamorphosis, the nematodes, which might or might not have an intermediate host, and those in the metamorphosis of which distinct stages occurred, the trematodes, cestodes and Acanthocephala, all of which had at least one intermediate host

An analysis of the results from an ecological approach to host–parasite relationships clearly shows the presence of two factors responsible for host distribution, namely, (*a*) the physiological requirements of each of the stages of the life-cycle , (*b*) the degree of morphological differentiation of the infestive larval stage These factors, being inherent to the class to which the parasite belongs, must have been acquired genetically and are therefore subject to mutation and to evolutionary pressures

Each successive stage of any life-cycle does not necessarily have identical physiological requirements, but the more highly specialized the latter the greater the degree of intimacy between the parasite and the host In trematodes, for example, host-specificity for the first intermediate host is more pronounced than in any of the subsequent stages, whereas in tapeworms the greatest degree of intimacy occurs with the definitive host In trematodes and acanthocephalians the infestive larval stage is already a completely formed young worm that only needs to mature and to grow to become adult Since the distribution of these parasites in their definitive hosts mostly follows the ecological pattern, it is probable that the physiological requirements of the adult worms are not highly specialized On the other hand, the infestive larvæ of monogeneans and tapeworms on reaching the definitive host must undergo further metamorphosis before acquiring adult characters The necessary conditions appear to be very strict and the more considerable the metamorphosis the greater the degree of host-specificity, the latter following the phylogenetical pattern Although there is, as yet, insufficient evidence for parasitic nematodes, it seems, however, that there might be a specific mechanism that triggers the final moults of the infective larva

Free-living flea larvæ require strict conditions as to temperature and degree of humidity, implying that their physiological requirements may be rather specialized But the legendary mobility of adult fleas and their resistance to starvation enable them to survive, but not necessarily to reproduce, by practising the art of host-hopping

During their entire life-cycle, biting and sucking lice remain attached to the host So it is not astonishing that their physiological requirements appear to be highly specialized as regards hair and feather structure In birds, their host distribution appears to reflect principally the latter

Summing up the effects of both external and internal factors responsible for parasite relationships we find that parasites do not select their habitat but that the latter is imposed by ecology The resulting distribution, however, also reveals another selective mechanism, namely, the degree of physiological and morphological adaptation of the parasites themselves

Prof W E Kershaw (Liverpool School of Tropical Medicine), in discussing the evolving human filariæ, suggested that it was more pertinent to consider their present evolution rather than what had happened in the past This was possible because of precise information of those pathogenic human parasites which it had been necessary to obtain urgently in order to devise economic and practicable control measures Their complicated life-cycles involved man, possibly other animals, and usually multiple species of vectors, each vector with its own sequence of environments The parasite, therefore, should be regarded as one component of a parasite–host–vector complex The true evolving entity was therefore not the parasite but the complex, which was evolving as were the separate components, and it was behaviour rather than structure which was critical

Loa loa, a parasite responsible for the recurrent and crippling so-called Calabar swelling, occurs in West and Central Africa There were two parasite–

host–vector complexes, an infection occurring in man and transmitted by two species of the vector genus, which bite during the day, and another occurring in three or more species of monkey which are adapted to different but related species of the vector which bite during twilight and at night. Both parasites were very closely related and differed only in their general dimensions and in their adaptation to different vectors. Each was well tolerated by the different vertebrate hosts and equally well transmitted by all the related vectors in the laboratory, but little interchange between these two populations occurred in Nature.

Malayan filariasis caused recurrent lymphatic inflammation and fever and often resulted later in the disabling permanent swelling of the limbs and the genitals known as elephantiasis; one form occurred in the north-west (periodic) and the other in the south and east of the Peninsula (non-periodic). The parasites responsible had only trivial structural differences, differing mostly in behaviour. In the 'periodic' form the larvæ were rarely found in the blood during the day, being most numerous at night. In the 'non-periodic' form, the larvæ were apparent during the day and night in similar numbers. The larvæ of these two forms behaved differently in the blood, they had different groups of vectors, and though both could be transmitted easily to cats, one form is not so well adapted to animals and occurs naturally only in man; whereas the other form is well adapted to animals and occurs naturally in man, in several species of monkey, in the domestic cat and in the pangolin.

In addition to these two infections in man, one of which is shared with many animals, there was a further and separate parasite which behaves a little differently from the other two, was transmitted by vectors somewhat different from the others and occurred in a very large range of animals, including the dog, the domestic cat, two species of wild cats and the civet cat, the tiger, the pangolin, the moon-rat and the slow loris, and could be transmitted experimentally to man and to the domestic cat. It had so far been found in the State of Pahang.

Work in East Africa had disclosed a fourth parasite, occurring in animals but not so far in man, closely related in structure to the two forms of human filariasis in Malaya and to that described in the State of Pahang occurring in a large range of animals. There were four related parasite–host–vector complexes, one of which had separated from the other three and was so far believed to be restricted to East Africa, and three occurred in Malaya. These three in Malaya are now evidently undergoing further divergent evolution, though their overlap is still very considerable.

Onchocerciasis caused skin changes and was associated with blindness in Central America and in tropical Africa. In the Americas, the adult worms occurred in nodules in the head and neck and eye changes were common, while in Africa they occurred on the lower part of the trunk and the legs, and eye changes were less common and occurred mostly in old-standing infections, so that they were once thought to be due to different parasites. In Africa the distribution of the larvæ in the skin had a very clear pattern both on the surface and in depth, and in early infections these larvæ were limited to the legs. Only when exposure to the infection had been repeated for many years did the concentration of larvæ rise and were they to be found in the upper parts of the body. While similar precise information was lacking in the Americas it seemed likely that the larvæ were most numerous in the head and neck. The vectors in Africa bit on the ankle and leg, and in America on the head and neck. These two different parasite–host–vector complexes have the same host and the same parasite, but differ in their manifestations because of the different behaviour of the two different groups of vectors.

The fundamental research undertaken to make it possible to devise economically practicable control measures has disclosed evolution in progress.

Dr. C. A. Wright (British Museum, Natural History) discussed the relation between trematodes and molluscs. The problem of speciation in the digenetic trematodes had received little attention. Isolation of some kind is an essential factor in the evolution of new species, and it is suggested that the part played by the molluscan intermediate host is of considerable importance in the speciation of flukes. The effective geographical range of a parasite is that area where all of the hosts necessary to the completion of the life-cycle occur together. The ecological requirements of most molluscs are such that a species is seldom uniformly distributed throughout its range but is broken up into separate populations between which there are varying degrees of isolation. These populations serve as the foci for the completion of fluke life-cycles and it is around these centres that the gene pools are formed from which new species may arise. There are three main factors in the maintenance of the purity of the gene pool, the geographical isolation of the locality, movement of the definitive host and the longevity of the adult parasite within that host. The third factor may partly offset the second for, if the parasite matures quickly, lays its eggs and dies, there is less chance of the eggs reaching other centres where the cycle could be completed even if the definitive host is very mobile.

The importance of host-restriction in the parallel evolution of host and parasite is of great significance, and the degree to which this phenomenon is shown in the relationship between larval flukes and their molluscan hosts is far greater than it is between the adult flukes and their vertebrate hosts. In those flukes which have a free-swimming miracidium there are at least two ways in which new fluke–mollusc relationships may occur. In the process of host-location by the miracidia the first stage is a response to physical stimuli which bring the larvæ into the region of the host-habitat. Thus, the substitution of a different mollusc having the same ecological requirements as the normal host may result in the adoption of this new host if its tissues provide an acceptable environment for further development of the larvæ. The last stage of the host-finding pattern by miracidia is a response to a chemical stimulus. Paper chromatography has shown the presence of species-specific substances in the body-surface mucus of freshwater snails and it is possibly these substances which enable miracidia to discriminate between potential hosts. It has now been shown that there exist differences in the composition of the mucus of snails of the same species from different populations and this may have great significance in the evolution of new mollusc–fluke relationships.

Dr. Theresa Clay (British Museum, Natural History) made some suggestions about the evolution of host–parasite relationships in the Mallophaga of birds. It was possible that the breaking up into non-breeding units by the birds during their evolution would result in isolated populations of Mallophaga and was analogous to the situation found on a group of continental islands the populations of which had become isolated by the disappearance of land connexions Later secondary infestations of Mallophaga from one host group to another are analogous to the trans-oceanic colonization of oceanic islands Successive colonizations and the occupation of the different ecological niches on the body of the bird could explain the number of different genera and species of Mallophaga found on one host species During the time that the Mallophaga were still partly free-living and before they had developed any close adaptation to life on the bird or to a particular bird species, interchange of host was presumably more frequent Thus, although birds within an order or sub-order are usually parasitized by related mallophagan faunas which have presumably evolved on these orders, the origins of related mallophagan faunas on different orders are difficult to assess In the affinities between mallophagan faunas of the birds[1], a diagram meant to demonstrate factually these affinities and not necessarily to suggest affinities between the host groups, the similarity of the mallophagan faunas of the Procellariiformes and those of the Charadriiformes, for example, may show no more than an ecological relationship, members of both orders living in the same environment The fact that in general the species on the two orders are now well differentiated suggests that, if this distribution is due to secondary infestations, it could not have been recent and supports the theory that establishment on a new host took place mainly in the early days of the evolution of host and parasite

Mr P F Mattingly (British Museum, Natural History) stated that the complete restriction of human and simian malaria to anopheline vectors suggests that this group may originally have evolved mainly as feeders on mammals Bird malaria, on the other hand, was carried exclusively by culicine mosquitoes which might thus have originated as feeders on birds The fact that human filariasis was carried by both anopheline and culicine mosquitoes suggested that it may have entered the system comparatively recently The comparative physiology and biochemistry of blood-meal utilization in mosquitoes had been very inadequately studied This was a particularly promising field for research which might throw light on many problems

Prof G C Varley (Oxford) believed that host specificity needed careful definition Not only must both host and parasite be accurately identified, but also those cases where a parasite can only complete part of its development must be distinguished Published lists unfortunately often gave equal emphasis to unique records and to regular parasite relationships

Prof Baer considered that the relation between a parasite and a group of hosts, related by ecology or phylogeny, was biologically significant, whereas the relation between one parasite and one host meant little

Prof Baer believed that the biochemical approach to species determination should be encouraged in the way that Dr Wright was applying it to snails, and that isolated proteins and carbohydrate fractions from hosts and parasites might be used

Dr J Sandground (New York) described his experience with onchocerciasis in Guatemala and in the Gold Coast, and referred to his demonstration some twenty years ago that the parasites in the New and Old World were identical He believed that much more work remained to be done in onchocerciasis before the infection could be understood adequately and before control would be easy

WILLIAM KERSHAW

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[1] Clay, T, First Symposium on Host Specificity among Parasites of Vertebrates, Neuchâtel, 120 (1957)

ANIMAL CLOCKS

THE significance of rhythmic activities in animal physiology is becoming increasingly evident to-day For this reason, the symposium on 'animal clocks' held in York on September 4, by Section D (Zoology) of the British Association for the Advancement of Science, was well timed During the morning sessions, Dr L Harrison Matthews, section president, was in the chair

The first speaker, Prof F A Brown, jun (Northwestern University), described recent research carried out in his laboratory In 1948 he had established that the frequency of the rhythm of colour change in fiddler-crabs was independent of temperature over a 20-deg C range Later it was shown that this 'indicator' process was itself regulated by a more fundamental rhythmic element and that two control centres were involved Although the concept of an autonomous clock is retained by most investigators, Prof Brown now postulated that the periodisms which comprise basic biological clock systems are imposed by environmental changes even in conditions hitherto presumed to be constant This hypothesis he supported by a detailed statistical analysis of data obtained by means of an automatic recording respirometer from organisms as unrelated as fiddler-crabs and potatoes which had been hermetically sealed in constant conditions including pressure, for several days at a time

Although other speakers did not agree with this view, all must have been stimulated to look more carefully at their own data Unfortunately, it has so far proved almost impossible to devise a really critical experiment that will differentiate between an innate clock mechanism and one derived from exogenous sources, since it appears possible, by analogy, to alter the position of the hands of the clock relative to the works Just as it is difficult to conceive of a distance-judging mechanism independent of space, so a clock system presumably requires some fixed points of reference

In a paper on the influence of the environment on the cyclical biting-behaviour of mosquitoes, Dr A J Haddow (director of the East African Virus Research Institute) pointed out that every species so far studied has shown a 24-hr periodicity In some, this is merely nocturnal or diurnal, but in others most of the activity is confined to one or two short and precisely delimited periods These, while usually very constant for a given environment, may be entirely different in another Further, they may show very striking differences at different levels above ground within the same environment At present, no single explanation fits all known cases

The complexity of natural internal timing mechanisms was illustrated by Dr Janet Harker (Department of Zoology, Cambridge), who described a series of elegant experiments by which she had been able to slow down part of the mechanism In cockroaches a hormone has now been discovered which increases the activity of the animal, and which is secreted in strict 24-hr cycles This hormonal clock can be stopped by chilling the secretory cells while the rest of the body is kept at a normal temperature, and when this is done a second clock associated with the nervous system is revealed When the secretory clock is allowed to start again, provided it has not got too far out of time with the nervous clock, it is reset by the latter However, in normal conditions the secretory clock acts as the master-clock, and since, like the nervous clock, it is not affected by sudden short changes in light conditions, the diurnal activity rhythm of the animal is little upset by such changes This may be important, in Nature, for animals which experience short periods of darkness during the day (for example, by going under a stone), or light at night (for example, bright moonlight or artificial light) If these minor changes in light conditions were to reset the clock, the animal would soon get out of time with day and night On the other hand, the fact that the secretory cycle can be affected by the nervous system clock towards the beginning and end of the dark period, and the activity rhythm can be immediately reset at these times, suggests a way in which the animal can allow for changing day-length

The morning session closed with an account by Dr C S Pittendrigh (Princeton University) of a coupled oscillator model for studying the behaviour of the innate circadian ('about a day') rhythm of cells and organisms Its further utility was noted in explaining recent discoveries in thermo- and photoperiodism Studies on the effects of single perturbations of the oscillator by light or temperature reflect the behaviour of a common underlying biological mechanism in some organisms, the phase of a rhythm can be shifted by a light signal as short as 1/2,000 sec It was concluded that the cell must comprise many diverse circadian oscillations, and disturbances of their mutual phase relations may lead to physiological stress or damage

Prof G C Varley (University of Oxford) presided over the afternoon sessions in which plant clocks were described by Dr M B Wilkins (King's College, London), with special reference to his own observations on excised leaves of *Bryophyllum fedtschenkoi* placed in continuous darkness and temperature These maintain a 22 4-hr rhythm in the rate of carbon dioxide output for several days The clock controlling the rhythm is extremely sensitive to changes in external conditions of temperature and illumination to which the leaves are subjected Continuous illumination inhibits the clock which re-commences when darkness is restored, the phase of the subsequent rhythm being determined by the time at which the light was extinguished The phase of a rhythm persisting in darkness is reset by applying a 3-hr light treatment to the leaves between the peaks but not at the crest of a peak Red light inhibits the rhythm, but blue light has no effect A rhythm can be induced in illuminated leaves by reducing the light intensity by at least 80 per cent, and it was later found that the phase of such a rhythm could be reset by applying a 3-hr dark treatment at the crest of a peak, but not between the peaks The rhythm is inhibited when the tissue is placed in an atmosphere of nitrogen and its period varies with temperature It is apparently unaffected by solutions of mitotic inhibitors such as phenylurethane and colchicine

Dr C G Butler (head of the Bee Research Department, Rothamsted Experimental Station) then surveyed the development of knowledge regarding the time-sense of the honey-bee since its fortuitous discovery in June 1905 by the famous naturalist, A Forel It was not until more than twenty years later that Ingeborg Beling carried out her extensive experiments in which bees were trained to visit a feeding place at different times of day under constant conditions Later workers have since obtained data which support the view that a honey-bee's time-sense depends in some way upon metabolic rhythm, since it can be speeded up or slowed down by the use of appropriate drugs Finally, bees trained in Paris to visit a feeding dish at a definite time each day have continued to maintain their feeding schedule under constant conditions after being flown to New York, thus demonstrating that the time-sense of the insects is endogenous

Dr A J Marshall (St Bartholomew's Hospital Medical College) introduced an exotic note when he discussed the possible influence of the internal rhythm of reproduction in the control of trans-equatorial migration of birds flying between Europe and Africa and Tasmania and the Aleutian Islands He pointed out that although something akin to a clock was involved, it had to be likened, nevertheless, to a somewhat imprecise, chain-store variety in that it had to be 'corrected' by environmental factors at least once during each annual cycle Work carried out by Dr D L Serventy and himself had made it clear that even when shearwater petrels (that breed on islands off the Southern Australian coast) were kept captive under widely varying conditions and day-length, they nevertheless came to breeding condition at the same time as the free birds that had made their astonishing circum-Pacific, trans-equatorial journey

Next, Dr J L Cloudsley-Thompson (King's College, London) discussed the synchronization of animal clocks in general, pointing out that endogenous rhythms are frequently correlated with environmental changes although they are not necessarily a direct response to them Thus, if cockroaches are subjected to alternating 12-hr periods of light and darkness, locomotion may actually begin shortly before the light is extinguished We have therefore the concept of an innate rhythm synchronized by changes in environmental factors such as light, temperature and humidity which should be regarded as 'clues' rather than stimuli

The field cricket, *Gryllus campestris*, placed in aktograph apparatus, can be seen to be active in the day-time with a rhythm that is endogenous and independent of temperature When the 24-hr periodicity has died away, however, after weeks in constant conditions, it can be re-established by a single exposure to light or by a return to higher temperatures after a period at 5° C The cricket's clock can be reset in this way, even when activity is completely suppressed by drought

Although light intensity is the chief factor by which animal clocks are synchronized, regular temperature changes can also be effective When night-active animals such as white rats, deer mice and millipedes are placed in constant light, it is found that their rhythms tend to be delayed while those of day-active forms are accelerated. The converse often occurs in constant darkness. In this way, diurnal rhythms can be shifted as the days lengthen or draw in according to the season. Synchronization with environmental changes cannot be achieved both at dawn and dusk as the time of each of these is altering. The 'clue' tends to be dusk in the case of nocturnal forms, dawn in that of day-active animals.

The symposium concluded with a paper by Dr. Mary C. Lobban (Department of Physiology, Cambridge), who said that in most communities man's activities are geared to a 24-hr. day. The clock which governs this periodicity is often difficult to reset, as those who travel great distances at the speed of modern aircraft well know. It is, however, possible to separate different physiological rhythms and to get them adapted to different degrees and at different rates. Recent work with indigenous Arctic peoples—Indians and Eskimos—indicates that environmental factors may influence physiological diurnal rhythms more than was hitherto thought. Temperature and physical exertion may well exert a profound effect in deciding whether an individual will become adapted successfully to a new time routine and even whether he will become adapted at all.

Both sessions were followed by lively discussions which served to emphasize the diversity of approaches to be found among workers on rhythmic phenomena. For example, Dr. William Gooddy (London) noted that no definition of a clock had been given by any speaker: the papers were concerned with the forms of rhythms and their possible causes. The definition of a clock as some form of regularly repeated natural phenomenon implies the presence of an observer, and each speaker had mentioned only those rhythmic processes which he had selected to be clock-forms for him. Since it is possible to study innumerable time systems, from the human time sense to the 'tides' inside single cells, the multiplicity and interaction of the mechanisms are evident. It might be wise to investigate organisms with nervous systems separately from plants. Though the cycles of some systems are related to the great events of astronomical observation, they will be modified by all other systems, perhaps giving rise to circadian cycles rather than exact 24-hr. cycles. Final or simple rhythms of an organism, including those described, must represent the average effect of all the possible clock forms observable by biologists in that organism. Too much analytical work on a system in isolation might obscure the general principles which may one day explain the mysteries of the human time sense.

Mr. P. F. Mattingly (London) pointed out that the study of arthropod-borne virus diseases had made it abundantly clear, despite the isolation of the virus in an intracellular environment, that its evolution has been conditioned by external factors no less than has that of the host. The integration of cyclical rhythms in animals is not merely a physiological problem but forms the basis of organic evolution itself.

Dr. E. T. Burtt (Newcastle upon Tyne) inquired whether different rhythmic activities might not profitably be regarded as portions of a continuous spectrum, but Dr. Cloudsley-Thompson replied that he believed there to be a hierarchy of mutually regulatory rhythmic patterns. Another speaker suggested that perhaps too much work had been devoted to arthropods, since inter-cellular transference of hormones is not the same in these animals as in vertebrates. (An instance is afforded by the sex hormones, the inter-cellular movement of which is so much reduced among insects that mosaic individuals can be formed.)

Dr. Sydney Smith (Cambridge) emphasized the dangers of lumping together a number of unrelated phenomena under ill-defined names such as rhythmic, or cellular activity—a trait as seductive as it is misleading. Finally, Dr. Harker pointed out that under conditions of desiccation the distribution of hormones within the insect body becomes blocked, owing to reduction in the amount of blood. This would explain the phenomenon observed in the field cricket.

J. L. CLOUDSLEY-THOMPSON

THE CONTINUED PROGRESS OF SATELLITE 1958δ_2 (SPUTNIK III)

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THE progress of the third Russian Earth satellite, 1958δ_2, from launching on May 15, 1958, until October 31, has already been reviewed by D. G. King-Hele[1]. From the latter date the responsibility of following the progress of the satellite and predicting its flight was taken over by the Radio Research Station, Slough.

For prediction purposes a period–time curve has been plotted, using radio and optical observations, and this is shown in Fig. 1. It is noticeable that the slope of the curve has been decreasing steadily throughout the period December–April: from November 1 to December 20, 1958, the mean rate of change of period was about 1.26 sec./day, from December 20 to February 28 about 1.17 sec./day, and from February 28 to March 31 about 1.11 sec./day. This decrease in slope, which arises from a lessening of atmospheric drag, is very probably a consequence of the fact that the southerly latitude of perigee, the point in the orbit at which the satellite experiences the greatest atmospheric drag, has been increasing since October 24, the date on which it crossed the equator. This movement has resulted in a net increase in the height of perigee above the Earth's surface, since the rate at which the Earth's radius has been decreasing with latitude has been greater than the rate at which the perigee distance of the orbit has been decreasing. A lessening

Table 1 ORBITAL ELEMENTS FOR SATELLITE $1958\delta_2$

Date	Nodal period of revolution (min)	Semi-major axis (km)	Eccentricity	Perigee distance (km)	Apogee distance (km)	Orbital inclination (deg)	Rate of rotation of orbital plane (deg /day)	Argument of perigee (deg)
1958 Nov 1 00	103 358	7295 8	0 0970 0 0968	6588 3 6589 4	8003 3 8002 2	65 16	2 67	356
Dec 1 00	102 664	7263 18	0 0930 0 0929	6587 3 6588 6	7939 0 7937 7	65 15	2 71	344
1959 Jan 1 00	102 013	7232 6	0 0894 0 0891	6586 2 6587 9	7879 0 7877 3	65 14	2 74	331
Feb 1 00	101 407	7203 9	0 0859 0 0856	6585 1 6587 3	7822 7 7820 4	65 13	2 78	319
Mar 1 00	100 791	7174 8	0 0823 0 0820	6584 0 6586 6	7765 2 7763 0	65 13	2 82	308
Apr 1 00	100 202	7147 0	0 0789 0 0785	6582 9 6585 8	7711 3 7708 3	65 12	2 84	298
May 1 00	99 647	7120 9	0 0757 0 0752	6581 8 6585 1	7660 1 7656 8	65 11	2 88	286
Accuracy	±0 005	±0 2	±0 0005	±1 0	±1 0	±0 01	±0 02	±1 0

Note Upper figures in columns 4, 5 and 6 were obtained assuming a scale height of 55 6 km (30 nautical miles), the lower figures correspond to a value of 37 1 km (20 nautical miles)

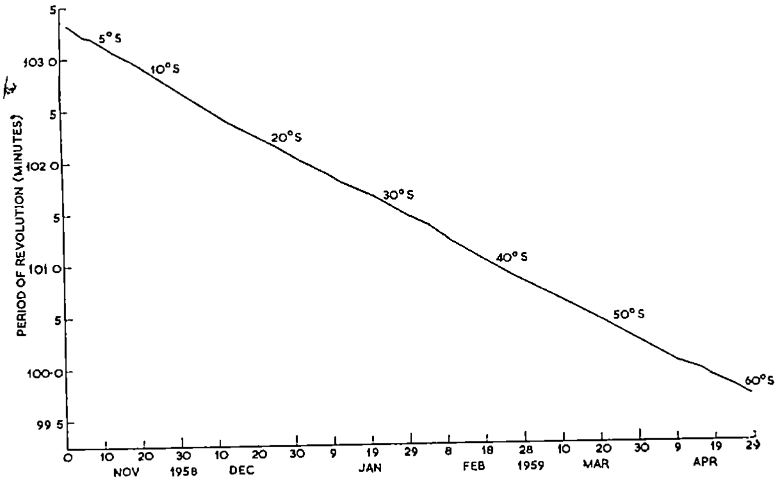

Fig 1 Nodal period of revolution of satellite $1958\delta_2$ (*Sputnik III*) Numbers on curve indicate latitude of perigee

of atmospheric drag follows from this increase in height Some idea of the increase in perigee height with increasing southerly latitude can be obtained from the following figures at latitudes 0°, 40° S and 60° S , the perigee heights were 210 9, 216 4 and 222 5 km , respectively, for a scale height of some 46 km (25 nautical miles) It is interesting to note that since March 25, 1959, the perigee of *Sputnik III* has been at a greater latitude than any other established satellite

Superimposed upon the smooth curve are numerous irregularities implying changes in the effective cross-sectional area of the satellite, or as is more likely, irregularities in atmospheric density at perigee Suggestions have been made as to the causes of these irregularities—discontinuities of density at the boundary of the light and dark sides of the Earth[2], solar disturbances[3]—though a discontinuity at about 28° S , corresponding to one detected at about 28° N by King-Hele[4], has failed to make an appearance

The irregularities in the period - time curve have made it difficult to forecast with any certainty the date of descent of the satellite During December 1958 a theoretical date of descent of about December 15, 1959, was indicated, but at the present time the expected date is nearer January 5, 1960

As an object for optical observations, the satellite has been comparatively faint since October 1958 due to its height, which has not been less than 460 km in the latitude of Great Britain On only a very few occasions has it been observed visually at stellar magnitudes brighter than + 3, and most observations have been made at magnitudes + 5 to + 7 During May, when the satellite was visible two and three times each night, its brightness remained fairly constant (though of an unpredictable magnitude) on any one transit, in contrast with the flashing nature of its appearance earlier this year The satellite is still transmitting on a frequency of between 20 004 and 20 005 Mc /s , though it has been reported from Australia[5] that the satellite does not now transmit a modulated signal when it is in the Earth's shadow Radio observers in Great Britain have had little opportunity of verifying this since, on transits within radio-range, the satellite has not been in the Earth's shadow since April 28

The initial elements of the orbit of the satellite, for epoch May 15 3, 1958, were nodal period, 105 975 min , eccentricity, 0 111 , perigee height, 226 km , apogee height, 1,879 km , and argument of perigee, 58° The elements for the period November 1, 1958–May 1, 1959, are given in Table 1 The nodal periods have been taken from the period - time curve used for prediction purposes The semi-major axis, eccentricity, perigee distance, apogee distance and the rate of rotation of the orbital plane have been calculated from the periods[6] The orbital inclination has been obtained by comparison with *Sputnik III* rocket ($1958\delta_1$), and the argument of perigee from a mean curve plotted using values from various sources including the Smithsonian Astrophysical Observatory As the value of the scale height at heights in the region of the perigee is uncertain, the eccentricity and the perigee and apogee distances have been calculated using two values of scale heights, 55 6 km and 37·1 km., the limits within which the true value is thought to be.

We should like to take this opportunity of thanking all those who have sent us observations on satellite $1958\delta_2$, both radio and optical.

The work described above was carried out as part of the programme of the Radio Research Board and is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

[1] King-Hele, D. G., *Nature*, 182, 1409 (1958).
[2] Groves, G. V., *Nature*, 182, 1533 (1958).
[3] Nonweiler, T. R., *Nature*, 182, 468 (1958).
[4] King-Hele, D. G., and Walker, D. M. C., *Nature*, 182, 860 (1958).
[5] Munro, G. H., *Nature*, 183, 1549 (1959).
[6] King-Hele, D. G., and Walker, D. M. C., *J. Brit. Interplan. Soc.*, 17, 2 (1959–60).

OBITUARY

Sir Ian Heilbron, D.S.O., F.R.S.

SIR IAN HEILBRON died in London at the age of seventy-two, following a short illness, on September 14. He was born in Glasgow in 1886, was educated at the High School and graduated from the Royal Technical College there. He had, as he was fond of recalling, decided upon chemistry as his career against family advice, but his choice was soon confirmed under the inspiring guidance of the late Prof. G. G. Henderson, for whom Heilbron acquired a life-long admiration. It was at Henderson's suggestion that Heilbron spent a two years tenure of a Carnegie fellowship from 1909 with Hantzsch in Leipzig. Here, a close companion of the late Prof. R. Robison, Heilbron developed a lasting interest in the application of spectroscopy to structural organic chemistry, and this experience seems to have led to the emergence of one of his marked characteristics, namely, a constant readiness to extract all possible assistance in the study of natural compounds by applying new physical techniques such as molecular distillation, chromatography and countercurrent distribution. However, his academic career at the Royal Technical College, Glasgow, where he was lecturer until 1914 and where he worked in purely synthetic organic chemistry, was interrupted by the First World War, in which he served with great distinction, eventually as assistant director of supplies in Salonika, and was awarded the D.S.O. After the War, he spent a short time with the then newly formed British Dyestuffs Corporation, but soon embarked upon a brilliant academic career, in which he successively held professorial chairs in Glasgow (1919–20), Liverpool (1920–33), Manchester (1933–39) and London (1938–49).

Heilbron's great and pioneering contributions to the study of natural compounds commenced in Liverpool. His early studies on the constituents of fish liver oils, notably squalene, led in turn to his introduction into Britain of micro-methods, to further his many investigations on the fat-soluble vitamins A and D, with which was associated in due course still wider exploratory work on steroids and carotenoids generally. It is perhaps ironical that he himself rarely shared fully in the culminating synthetic triumphs which were often based on the difficult and arduous work which he had long ago instituted with such conspicuous acumen, courage and determination. However, outstanding as were his many direct contributions to knowledge, as reflected, for example, in some three hundred original publications, and his bringing into being with H. M. Bunbury the "Dictionary of Organic Compounds", his indirect contributions to chemistry in general were perhaps unequalled. Repeatedly he equipped laboratories with unsurpassed vision so that each is now a thriving centre of research. Above all, he inspired a host of younger chemists, many of whom now occupy leading positions in universities or industrial life in Britain and abroad.

The Second World War naturally brought Heilbron again to the service of his country ultimately as scientific adviser to the Ministry of Production, where he played an important part in introducing DDT, and as a result was knighted in 1946. All these duties, discharged with a precision and penetration which constantly surprised his associates, were assumed, however, in addition to his academic work, which went on at an accelerated rather than a reduced rate and led later to a new spate of publications on such different topics as the chemistry of the steroids, acetylenic compounds and penicillin. Moreover, by this time his unique experience was widely sought in such capacities as chairman of the Colonial Insecticides Committee, as a member of the Advisory Council of the Royal Military College of Science and of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research, and in reorganizing the International Union of Pure and Applied Chemistry. While in the midst of these activities he relinquished his academic post at the Imperial College of Science and Technology, London, to become director of the Brewing Industry Research Foundation (1949–58), which owes so much to his versatility, energy and genius.

Heilbron's scientific life began when the study of chemistry and particularly of natural compounds was scarcely more than an academic pursuit; but he lived to see many of the methods and techniques which he had sponsored become general tools of research and many of his research projects develop into substantial segments of chemical industry. It is not surprising, therefore, that he received wide recognition in the form of numerous awards and honorary degrees, both in Britain and overseas. Any mere catalogue of these achievements and distinctions could, however, convey little real impression of his great qualities as a man. Lucidity, constructive imagination and an almost intuitive insight into the complexities of scientific effort were among many similar characteristics which were almost immediately apparent to all with whom he came into contact. Those somewhat closer, as in the departments which he directed, came also to recognize his generosity, scrupulous fairness and invariable feeling of fatherly concern for even the most junior members of his staff. To those privileged to know him still better, his quick sense of humour, keen appreciation of the arts and, above all, the spontaneous assured wisdom with which his lively mind abounded, made him an unforgettable and delightful personality He is survived by two sons, but the sudden death of his wife, Elda, in 1954 was a sad blow which affected him far more deeply than many who knew him may have realized

A H Cook

My close friendship with Ian Heilbron dates from near the end of the First World War and arose from many common interests and activities These included consultation with industrial research groups, membership of committees under government auspices and tenure at different times of the chairs of organic chemistry at the Universities of Liverpool and Manchester Heilbron was, of course, an illustrious organic chemist whose reputation was world-wide and whose original work could justly be described as pioneering As Dr Cook has pointed out, he did not always enjoy the full fruits of his labours Others stood on his shoulders and were thus enabled to reach higher A part of his work was in fields of potential commercial importance and doubtless for this reason some of his discoveries were impatiently exploited

Heilbron had much courage of his very firmly held convictions, and did not fail in finding words to express them He caused many a breath of fresh air to pass over the conference tables, especially when he thought progress was too slow or where he detected evidence of red-tape mentality

His contributions in the Second World War were extremely valuable If he had not been a scientist he could have become a most successful business man and his executive activity was characterized by promptitude and efficiency Every laboratory which came under his charge was greatly improved, not merely by new construction but also by better considered organization of existing facilities His attention to detail in these connexions was very characteristic As an investigator he also excelled in planning the campaign and was instrumental in the introduction of important novel techniques

In private life his friends found him quite charming, an excellent host and a greatly appreciated guest He was fastidious and had a most sensitive appreciation of the fine arts Above all he was a warm-hearted, generous man who devoted himself to public service and to the progress of science

R Robinson

NEWS and VIEWS

Astronomy at St Andrews Prof E F Freundlich

Prof E Finlay Freundlich, who four years ago retired from the Napier chair of astronomy at St Andrews, relinquishes now also his directorship of the University Observatory Prof Freundlich started his astronomical life some forty years ago at the Berlin Observatory Much of his work was determined by an early association with Einstein which made him pursue the question of observational tests of the theory of relativity In order to investigate the predicted red-shift of spectrum lines, Freundlich created in the early 'twenties at Potsdam the well-known Einstein Institute with its tower telescope The new solar installation, among the best of the time, produced new observational evidence on the 'limb' effect, and also important pioneer work on line profiles Freundlich's main contribution to the field of relativity astronomy is undoubtedly his eclipse work on the deflexion of light at the Sun's limb His results of 1929 are still among the best obtained on this extremely difficult problem, and his conclusion that the observed deflexion exceeds the theoretical value is now generally accepted Prof Freundlich left Germany in 1933 and after a few years in Istanbul and Prague settled in St Andrews in 1939 Here he became interested in the design of a large Schmidt–Cassegrain telescope A 19-in pilot model was successfully set up in 1950, and the main parts of the full-size 37 in telescope are now nearing completion In the University, Freundlich instituted an honours course in astronomy, in which he paid particular attention to his favourite subject of celestial mechanics It is pleasing to know that when Prof Freundlich returns to his native Rhineland, an association with the University of Mainz will allow him to retain an active interest in astronomy

Prof D W N Stibbs

Dr D W N Stibbs succeeds Prof E Finlay Freundlich in the Napier chair of astronomy at St Andrews A graduate of the University of Sydney in physics in 1942, Dr Stibbs gained his early astronomical training at the Commonwealth Observatory under the Astronomer Royal, Dr R v d R Woolley , afterwards they were co-authors of the well-known monograph "The Outer Layers of a Star" Engaged as lecturer in mathematical physics at Armidale in 1942, Dr Stibbs was seconded from there to work for the Royal Australian Air Force on the influence of the ionosphere on radio direction-finding He returned to Canberra after the War and was appointed Radcliffe Travelling Fellow in Astronomy in 1951, and worked first at the Radcliffe Observatory, Pretoria, and afterwards at Oxford where he gained his D Phil in 1954 In 1955 he joined the Theoretical Physics Division at the Atomic Weapons Research Establishment, Aldermaston, where he has been engaged in theoretical research on the interaction between radiation and matter under stellar conditions He is probably best known for his fundamental work on the motions of the southern galactic Cepheids as determined from his own consummately planned observations at the Radcliffe Observatory In a discussion of the motion of these stars and of those earlier observed by Joy at Mt Wilson, Dr Stibbs revealed a marked discrepancy in the neighbourhood of the galactic centre between the rotation of the Cepheid System and the neutral hydrogen clouds

California Institute of Technology

Dr Richard P Feynman

Dr Richard P Feynman has been appointed Richard Chace Tolman professor of theoretical physics at the California Institute of Technology The trustees created the new chair in physics in honour of the memory of the late Dr Richard Tolman, an internationally known theoretical physicist and chemist who for years was dean of graduate studies at the Institute Dr Feynman is considered to be one of the world's outstanding theoretical physicists for his contributions to the understanding of atomic structures and quantum mechanics. Recently, in collaboration with Dr. Murray Gell-Mann, of the California Institute of Technology, he developed a theory of weak interactions, which govern the electron and positron in radioactivity. Dr. Feynman graduated from the Massachusetts Institute of Technology and received his Ph.D. at Princeton University. As a scientist with the Manhattan Project, he is credited with making important contributions toward developing the atomic bomb. In 1954 he won the Albert Einstein award, one of America's highest scientific honours.

Ministry of Supply: Director of Materials Research and Development

The retirement of Dr. H. Sutton in August from his present post as director of Materials Research and Development (Air) marks the end of the full-time service of a most distinguished metallurgist who has given the whole of his professional life to the public service. Dr. Sutton was educated at King's School, Macclesfield, took his first degree in chemistry at the University of Manchester, later the degree of M.Sc. and in 1935 he received the degree of D.Sc. In the First World War he served as research assistant to Prof. C. A. Edwards, who was then the regional controller and adviser in Manchester to the Ministry of Munitions. His departure, therefore, severs one of the rare personal links of the present Ministry of Supply with one of its predecessors, the Ministry of Munitions. Joining the Royal Aircraft Establishment at Farnborough in 1918 he was appointed the head of its Department of Metallurgy in 1925, a post he retained until 1943 when he was transferred to the headquarters post which he has built up, largely through his own personal and professional qualities, to the important position it now holds in the field of British metallurgy, especially in relation to aeronautics.

Dr. Sutton was a pioneer in the work on the formulation and fabrication of light metal alloys, without which aircraft in their present form would not be known. He was also early in foreseeing some of the special dangers to which they are subject in relation to crack formation, brittleness and the like. In later years, while never discarding his first interests in aluminium-based alloys, he has been forward in promoting work on titanium and other possible more novel metals. At the same time, as the scope of his duties has widened, he has seen to it that much attention has been given to the non-metallic materials that play so important a part in the construction of modern aircraft. A prolific author of papers on metallurgical subjects published in most of the metallurgical journals, he has been honoured during his career by the award of the Simms Gold Medal and the Silver Medal of the Royal Aeronautical Society. He is a Fellow of the Royal Aeronautical Society, a founder Fellow of the Institution of Metallurgists and a member of all the relevant professional societies. His professional advice has been widely sought by committees in government and industry and he has been unsparing in forwarding those subjects to which he has devoted his life.

The Council for Nature

At the recent annual general meeting of the Council for Nature the following resolutions were passed:

"The Council for Nature fully shares the great concern of naturalists in Britain at the threats to the remaining undeveloped areas of the country's coastline by industrial and other developments and considers that the importance of those areas, both for scientific study and for the conservation of wild life no less than for the preservation of amenity and opportunities for recreation, calls for a halt to the process of spoliation. The Council therefore urges that a meeting of the national bodies interested in the matter should be convened by the Nature Conservancy at an early date with a view to pressing for vigorous action including a review of the principles at present governing the siting of nuclear power stations.

"The Council for Nature welcomes the public-spirited action of a large firm of manufacturers in withdrawing recently their supplies of arsenical spray. The Council, while recognizing the need for the use of toxic sprays (subject to proper safeguard), urges the Government to control the wholesale application of agricultural sprays the cumulative effect of which is still unknown, but which have been, or may be, damaging to so many plants and animals, including such useful insects as bees. The Council urges further that the use of arsenical sprays should be prohibited or restricted forthwith, and that the Government and its agencies should give high priority to the research needed into the long-term effect of toxic sprays on the complex life of the countryside."

Canadian Institute of Oceanography

The Canadian Government as well as the universities are showing rapidly growing interest in the scientific study of the oceans. An annual grant of 90,000 dollars to Dalhousie University was made by the National Research Council of Canada, for the establishment of an Institute within the University to teach and promote research (see *Nature*, 183, 1161; 1959). The Department of Mines and Technical Surveys has now announced its intention to set up a new three-million dollar laboratory in Bedford Basin at the head of Halifax Harbour only a few miles from the University. The project means the building up in the neighbourhood of Halifax and Dartmouth of a strong centre for marine sciences. It will include the Atlantic and sub-Arctic sections of the Canadian Hydrographic Service, the oceanographers, hydrographers and geologists who work in the Arctic and the Atlantic Oceanographical Group of the Fisheries Research Board. Ten new ships to serve them are already being planned and the first, the C.G.S. *Hudson*, costing seven million dollars, is expected to be commissioned in 1961. The main purpose of the new laboratory, which will be called the Bedford Institute of Oceanography, is to study the physics of the water and the sea bed, but provision is made for close co-operation and liaison among all aspects of the subject, and with the rapidly growing effort on the Pacific coast and work on the Great Lakes. In making the announcement the Ministry of Mines and Technical Surveys stressed the importance of a better understanding of the oceans to science, defence, commerce, and development of the country's resources.

Reconstruction of Brazilian Library

An appeal for help to reconstruct the library of the Brazilian Centre for Physics Research, damaged in a recent fire, has been launched by Unesco and the International Atomic Energy Agency. At a meeting of Unesco's Executive Board in Paris in June, Prof. P. de B. Carneiro stated that the Centre's collection of works on nuclear physics and higher mathematics, the only one of its kind in Latin America, has been almost entirely destroyed. The Executive Board responded to the appeal by recommending a number of measures to provide international aid from Unesco, the International Atomic Energy Agency and the U.N. Technical Assistance Administration. The library has been added to the list of projects for which Unesco gift coupons may be given. Universities, libraries, technical institutes, non-government organizations, and governments of Unesco's Member States have also been asked to contribute. Organizations or individuals wishing to help in the restoration of the library may write to Centro Brasileiro de Pesquisas Fisicas, 71 avenida Venceslas Braus, Rio de Janeiro, Brazil. All offers of books, micro-films, extracts or other documentation should be made directly to the Centre. Gifts of money may be sent in the form of Unesco Gift Coupons, about which information may be obtained from the Public Liaison Division, Unesco, Place de Fontenoy, Paris 7e.

Grants for U.K. Students

THE 1959 Grants Year Book, the fourth to be issued by the National Union of Students (1959 Grants Year Book. Local Education Authority Awards to Students. Pp. 107. London: National Union of Students, 1959. 2s. 6d.), comprises a detailed guide to the values of awards paid by the Ministry of Education and the Local Education Authorities to students taking courses of higher education and to the regulations governing those awards. These details are arranged by counties and county boroughs and there are appended notes on university and technical college awards, on training college awards, postgraduate awards of the Department of Scientific and Industrial Research, and other bodies. An account of the new system recently introduced in Northern Ireland is included, and there is a general survey of awards, 1958–59, based on information received since November 1958. An introduction to the Year Book urges the importance of further expansion of the teacher training colleges and stresses the need for a national scale of minor awards assessed on the same basis and principles as the major awards to eliminate the present wide variation in minor awards for technical and similar courses. Attention is directed to the wide variations between the local education authorities in number of awards shown by the Ministry of Education's published statistics.

Research in Dairying

IT is not often realized that the milk produced in the United Kingdom nowadays amounts to about 2,200 million gallons a year and is worth about £1 million a day. An industry of such magnitude and importance surely deserves a first-class research service. The fact that it has got such a service can be seen from the annual report of the National Institute for Research in Dairying for 1958 (pp. 154. Shinfield: National Institute for Research in Dairying, University of Reading, 1959. 4s.). It is clear from the report that the Institute is making a very thorough study of the scientific principles on which the art of dairying is based, by doing research work of a high quality on fundamental problems, such as digestion and metabolism in the ruminant, the biochemistry and physiology of milk secretion, and also on problems of an immediately practical nature such as those concerned with the growing of crops for feeding dairy cattle, the milking technique itself and many technical and engineering problems associated with the handling and processing of milk and the manufacture of milk products. The report contains an informative description of the work that is being done in each department of the Institute, and some of the more significant of the recent findings are summarized in a brief outline which gives information on about thirty of the many different items under investigation. A well-deserved tribute is paid to Prof. H. D. Kay, who retired last year after being director of the Institute for more than twenty-five years, and also to the Earl of Iveagh, who has resigned from the board after a long period of service in which he did so much for the welfare of the Institute and its staff. The report includes a detailed list of 182 papers that were published in the period under review.

Mathematical Games

AMONG the many aspects of Japanese culture that have recently engaged the interest of Americans is 'origami', the ancient Japanese art of paper-folding. Several books on the subject are now available in English, an origami workshop flourishes in Manhattan and the country's first paper-folding exhibit was open to the public at Cooper Union's Museum for the Arts of Decoration in New York (*Scientific American*, 201, No. 1, July 1959).

The origins of origami are lost in early Oriental history. Folded-paper birds appear as kimono decorations in eighteenth-century Japanese prints but the art is many centuries older in both China and Japan. At one time it was considered an accomplishment of refined Japanese ladies; now its chief practitioners seem to be geisha girls and Japanese children who learn it in school. During the past twenty years there has been a marked upsurge of interest in origami in Spain and South America. Traditionally, origami is the art of folding realistic animals, birds, fish and other objects from a single sheet of paper, without cutting, pasting or decorating. The attraction of origami lies in the extraordinary realism that can be obtained with nothing more than a square of paper and pair of deft hands. A sheet is folded along geometrical lines. Suddenly it is transformed into a delicate piece of miniature semi-abstract sculpture of considerable beauty.

In view of the geometrical aspect of paper-folding, it is not surprising that many mathematicians have been fascinated by this art. Lewis Carroll, for example, was an enthusiastic paper-folder. The literature of recreational mathematics includes many booklets and articles on folded-paper models, including those curious toys called flexagons. The folding of regular polygons, though not part of classic origami, is a challenging classroom exercise. The equilateral triangle, square, hexagon and octagon are quite easy to fold, but the pentagon offers special difficulties. Paper can also be folded to produce tangents that have as their envelope various low-order curves. The parabola is particularly easy to demonstrate. Closely related to this folding procedure an interesting problem in elementary calculus can be demonstrated. The most remarkable of all origami constructions is, however, the bird that flaps its wings. A number of origami animals have action features: a fish that opens its mouth, a frog that hops when its back is stroked, and so on.

International Combustion Symposium

THE report of the Seventh Symposium (International) on Combustion, the first of the International Combustion Symposia to be held outside the United States, has been published (Pp xxvi + 959 London Butterworths Scientific Publications, 1959 224*s*) It contains 124 original papers presented during August 29–September 3, 1958, at Oxford Few who have a serious interest in combustion will fail to profit from a study of its pages The largest of the eleven groups of papers concerns the chemistry of combustion reactions, and there are three important groups devoted respectively to deflagration, detonation and combustion in flowing systems Smaller sections are concerned with spectroscopy, ionization and turbulence in flames, the last containing particularly welcome contributions to a difficult and, until recently, neglected subject. The section on ignition and limits of inflammability attracted mainly papers on the former subject, while that on the interaction of flames with surfaces proves to be a repository for papers on a variety of loosely related topics The section on special fuels is disappointingly short and the final group of papers on instrumentation is characteristically miscellaneous

The editors and publishers are to be commended on at least two counts For the first time the volume appeared with a delay of little more than six months after the meetings Furthermore, there is for the first time a rational and almost complete record of the discussions One suggestion still remaining to be implemented is that the papers should be provided with a uniform type of summary or abstract Will the Eighth Symposium book display every virtue of its kind ? The present volume has not fallen far short of doing so

Computer Applications

THE report of the proceedings of the fifth annual Computer Applications Symposium, held in Chicago during October 29–30, 1958, has now been published (pp x + 153 Chicago, Ill · Armour Research Foundation of Illinois Institute of Technology, 1959 3 dollars) It covers the whole range of applications of computers and some two-thirds of the papers are concerned with data processing or computer organization, even though sometimes labelled as engineering and scientific, as, for example, the papers by R A Haertle on "Use of a Computer in the 'AC' Spark Plug Division of General Motors", and by E M Chastain and J C McCall on "Computer Sharing by a Group of Consulting Engineering Firms" At first reading it would appear that the United States is much ahead of Britain technically in dealing with data processing and large-scale scientific work, but perhaps it is in the attitude of mind towards application of the computer to this type of work that Britain is really behind The breadth of vision shown in papers such as that of Col Ellett, dealing with the data processing for air material command, and the willingness to attempt the 'blue skies' approach indicated both there and in the paper by R D Whisler on work at Johnson's Wax, is very impressive It contrasts markedly with the timid and hesitating steps being taken in Britain and is a measure of the confidence now felt in the United States in the capacity of computers to carry through data processing economically On the technical side, one or two papers are of particular interest, such as that of R W. Hamming on "Frontiers of Computer Technology", and that of W F Bauer on "The Future of Automatic Programming" On the whole, it is an interesting report, but not of special interest to the general scientific reader, except to demonstrate the very wide field over which computers are now applied

Guatemalan Flora

THE Flora of Guatemala is continued with a part devoted to a number of families of Gymnosperms and Monocotyledons, including the large Cyperaceae, Palmaceae, Araceae and Bromeliaceae (Chicago Natural History Museum Fieldiana Botany Vol 24, Part 1 Flora of Guatemala By Paul C Standley and Julian A. Steyermark Pp ix + 478 (121 figures) (Chicago, Ill Chicago Natural History Museum, 1958) 8 dollars) There is a number of helpful illustrations It must be remembered that this work also deals with the flowering plants (and their vernacular names) of British Honduras, "since on both geographic and botanical grounds it is essentially a part of Guatemala" This part opens with a plan of the Flora, and mentions certain areas of Guatemala which still need further exploration

Space Projectiles

THE Russian journal *Priroda* has recently published a series of articles dealing with various types of space projectiles launched in the Soviet Union and the type and methods of observations connected with these projectiles Thus Y L Alpert (10, 71 , 1958) discusses the study of the ionosphere, V I Krasovsky (12, 71 , 1958)—the study of the upper atmosphere, A E Chudakov (12, 88 , 1958)—the study of photons, N A Dobrotin (1, 57, 1959)—the study of cosmic rays, N S Yakhontova (4, 5 , 1959) presents an account of the small artificial planet launched in January, and, finally, V L Kurt (5, 74 , 1959) discusses the artificial luminous sodium comet

New Radioisotope Training Programme

THE Atomic Energy Commission of the United States has announced a new programme which will provide students of undergraduate colleges with the opportunity for specialized training in the techniques of using radioisotopes The new programme will utilize a mobile training laboratory which can be moved to the college campus for presentation of a short (two-week) concentrated course on the basic techniques of handling radioisotopes The laboratory will be similar to one presented last year to the International Atomic Energy Agency by the United States Further information is available from University Relations Division, Oak Ridge Institute of Nuclear Studies, P O Box 117, Oak Ridge, Tennessee

Animal Health Trust Awards, 1959–60

THE Animal Health Trust has announced the following senior awards for the period 1959–60 *Wellcome Fellowships* Mr P H Lamont to undertake investigation of enteroviruses of the pig, and their possible role, in disease, at the Department of Animal Pathology, Cambridge, under Prof W I Beveridge , Mr I R Falconer to study thyroid–ovarian–pituitary interrelationship at the Department of Biological Chemistry, University of Aberdeen, under Dr H A Robertson *Vitamealo Fellowship* This new award was founded to commemorate the 70th birthday of Lord Rank and his close association with Vitamins, Ltd , by whom it was given The first recipient is Mr D B Ross, who is to continue work on some of the more fundamental aspects of magnesium metabolism, particularly intestinal absorption Initially Mr Ross will work at the Department of Animal Pathology, Cambridge *Research Training Scholarship* Mr W A G Charleston to undertake an investigation into the mechanics of the quadrupedal vertebral column, with special reference to the dog and the cat, under Prof C W Ottway at the Department of Veterinary Anatomy, University of Bristol Eight Evans Final Year Scholarships have also been awarded

The International Nickel Company of Canada, Ltd., Fellowship

The establishment of a fellowship to honour the visit of H M the Queen and H R H Prince Philip, Duke of Edinburgh, to the nickel mines in the Sudbury area has been announced by the International Nickel Company of Canada, Ltd , and the Canada Council (the latter being a body established by the Canadian Government for the encouragement of the arts, humanities and social sciences) The fellowship will be called 'The Queen Elizabeth II Fellowship (The International Nickel Company of Canada, Limited, Royal Tour, 1959)' The award will be a postdoctoral fellowship tenable for two years Research can be undertaken in the chemistry or physics of metals, geophysics, geology, metallurgy, mineralogy, or mining Candidates must be Canadian citizens and holders of a doctor's degree and the fellowship must be held at a Canadian university The International Nickel Company has deposited 15,000 dollars with the Canada Council, which will supervise all arrangements for the fellowship

The Night Sky in November

Full Moon occurs on Nov 15d 09h 42m U T and New Moon on Nov 30d 08h 46m The following conjunctions with the Moon take place Nov 4d 16h , Saturn 5° S , Nov 27d 02h , Venus 0 6° N In addition to these conjunctions with the Moon, Mercury is in conjunction with Jupiter on Nov 7d 10h , Mercury being 3 4° S , Mercury with Antares on Nov 10d 05h , Mercury being 2 0° N , Jupiter with Antares on Nov 15d 16h , Jupiter being 5 2° N , Mercury with Jupiter on Nov 17d 06h , Mercury being 2 1° S , Mercury with Antares on Nov 17d 21h , Mercury being 3 3° N , and Venus with Spica on Nov 30d 05h , Venus being 4 5° N Mercury is too close to the Sun for observation Venus is a morning star, rising at 2h 35m , 2h 55m and 3h 25m on November 1 15 and 30, respectively , its stellar magnitude is −4 0 Its distance increases during the month from 55 to 77 million miles and the visible portion of the apparent disk increases from 0 443 to 0 598 Mars and Jupiter are too close to the Sun for observation Saturn sets about 2 hr after the Sun, and will be visible low in the southwest after sunset , conditions are not favourable for observation Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich Nov 4d 17h 47 6m , *Y* Sgr (*D*) , Nov 5d 17h 23 7m , ρ Sgr (*D*) , Nov 14d 3h 53 9m , ξ Ari (*D*) , Nov 16d 18h 32 0m , α Tau (*D*) , Nov 16d 19h 28 9m , α Tau (*R*) *D* and *R* refer to disappearance and reappearance, respectively The Taurid meteors are active during the first fortnight of the month, conditions being moderately favourable , the radiant is near R A 3h 36m , Dec + 14° The Leonids are active during November 15–17, but conditions are unfavourable for observation

Announcements

The first Polarographic Society Medal has been awarded to Prof J Heyrovský for his discovery of the polarographic method in the nineteen-twenties and for the subsequent major contributions to the subject by himself and his students

Dr W M Hampton, of Chance Brothers, Ltd , will deliver the Fifth Chance Memorial Lecture of the Society of Chemical Industry under the title "The Development of Furnaces for Glass Melting" The Lecture will be delivered on February 9 in Birmingham

Dr Ainsley Iggo, of the Department of Physiology, University of Edinburgh, has been appointed by the Royal Society to a Locke Research Fellowship Dr Iggo will continue his research at Edinburgh on unmyelinated afferent nerve fibres their peripheral specificity and their central connexions

Prof A L Hodgkin, Royal Society research professor in the University of Cambridge, and Prof R Milnes Walker, professor of surgery in the University of Bristol, have been appointed members of the Medical Research Council in succession to Prof R C Garry and Mr H J Seddon, who are retiring after their normal four-year term of service The Committee of Privy Council has also recently appointed Sir Hugh Linstead as the House of Commons member of the Council in succession to the late Richard Fort

The Bibliography of Scientific Publications of South and South-East Asia for June 1959 (No 6, Vol 5) compiled jointly by the Unesco Science Co-operation Offices for these areas and published by Insdoc, National Physical Laboratory, New Delhi, lists by subject a further 102 titles

The Committee on Fire Research and the Fire Research Conference of the Division of Engineering and Industrial Research of the U S National Academy of Sciences–National Research Council is planning a two-day international symposium on the theme "The Use of Models in Fire Research", to be held at the National Academy of Sciences in Washington, D C , during November 9–10 Further information can be obtained from Mr D W Thornhill, Executive Secretary, Committee on Fire Research and Fire Research Conference, National Academy of Sciences, 2101 Constitution Avenue, Washington 25, D C

Awards for study in statistics by persons whose primary field is not statistics but one of the physical, biological or social sciences to which statistics can be applied are offered by the Department of Statistics of the University of Chicago The awards range from 3,600 dollars to 5,000 dollars on a nine months basis or 4,400 dollars to 6,000 dollars on a basis of eleven months The closing date for application for the academic year 1960–61 is February 15, 1960 Further information can be obtained from the Department of Statistics, Eckhart Hall, University of Chicago, Chicago 37, Illinois

Erratum In the communication entitled "Incorporation of DL-[2-^{14}C] Mevalonic Acid Lactone into Polyisoprene", by R G O Kekwick, B L Archer *et al* , in *Nature* of July 25, on p 270, col 1, line 1, for "active" read "inactive"

THE NATIONAL PHYSICAL LABORATORY

THE National Physical Laboratory held two open days on May 27–28, when about 3,500 guests from industry, the universities and Government departments viewed 150 exhibits covering the main items of the current research programmes. As last year, the exhibits were chosen to illustrate certain selected topics, but arrangements were made for visitors to discuss with specialist members of the staff items of work not on display.

The nine scientific divisions of the Laboratory function largely as independent units, but in a number of cases the programmes involve close collaboration between divisions. This is particularly the case with the work of Mathematics Division, much of the work of which consists of providing advice and computing facilities to other divisions. Excellent examples of the fruitfulness of such collaboration were seen in the work on machine-tool control by the use of diffraction gratings, shown by the Light Division, and in a new infra-red spectrometer exhibited by the Basic Physics Division.

The measurement of fundamental standards has always been one of the basic responsibilities of the Laboratory, and a reorganization of Divisions in 1958 brought such measurements mainly within the fields of the Standards and Applied Physics Divisions, with the newly created Basic Physics Division concerned with more fundamental research in some newer fields.

In an experiment designed to measure the gyromagnetic ratio of the proton, apparatus for which was exhibited, the Standards Division is extending its field of endeavouring to relate measurement to atomic constants. A magnetic field about twenty times the strength of the Earth's field is produced by means of a known electric current in wire coils of known dimensions. At the centre of the coil system a spherical container is filled with water, the source of the protons. The latter are polarized in a direction perpendicular to the known field by a current maintained for a few seconds in a coil surrounding the sphere. When this polarizing field is removed the protons return to a state of equilibrium over a period of about 2 sec., during which time an e.m.f. is induced in the polarizing coil, now used as a pick-up coil. The frequency of this e.m.f., about 40 kc./s., is measured, and from it and the known applied field the gyromagnetic ratio is calculated. This constant is of importance for defining stronger magnetic fields, which may then be used for the determination of e/m for fundamental particles.

The tendency to relate all standards to more fundamental quantities is also seen in the use of monochromatic radiation as a fundamental standard of length. The precise intercomparison of wave-lengths has thus become of increased importance, and a high-resolution spectrometer for this purpose was shown. It uses the method of air-pressure variation to scan the fringes of a Fabry–Perot interferometer, but, since the instrument is illuminated with light of the two wave-lengths to be compared in very rapid alternation, it is not necessary to measure the absolute pressure of the air very exactly. In synchronism with the rotating 'chopper' shutter the output of the receiving photomultiplier is switched to two amplifiers. Errors due to changes of source intensity are eliminated by an additional photocell measuring the ratio of transmitted to incident light. The variation in intensity of the centre fringe with pressure for the two sources being compared is recorded on a chart recorder. Arrangements are also fitted for digitizing the records on punched tape, which can then be fed to a computer for Fourier analysis to obtain data on phase shifts at the semi-reflecting surfaces and other information. The instrument will be used for comparisons of standard wave-lengths, measurements of isotope shifts and work with sources at liquid-helium temperatures.

Another new field of standardization, undertaken in the Applied Physics Division, is that of neutron sources, required to produce known neutron fluxes for work in problems of reactor design. The strengths of the sources are compared by suspending them overnight by a fine thread at the centre of a large spherical container filled with manganese sulphate solution. A correction is applied for the neutrons escaping from the vessel. The amount of manganese-56 produced is determined by β-decay measurements, which are compared with those obtained after the addition of a known amount of active manganese to the same container. It is also hoped to obtain a confirmatory measurement from the amount of helium produced in three sources over a period of time. Six British sources have been compared with a Canadian standard.

The same Division has several rooms specially designed for the measurement of sound, but this is a field in which subjective measurements are of more than usual importance. The results of extensive experiments on the loudness of directional sound fields, as measured by pressure at the listener's ear, were shown. Such measurements, however, do not indicate the total loudness to a listener, owing to the additive effects of both ears. Charts were also shown for a group of observers, showing that the directional arrival for maximum loudness varies in a complicated way with frequency. An approximate binaural summation theory has been developed, from which some calculations of loudness have been made; these compare fairly well with the results of direct measurements.

The newer programmes in the Basic Physics Division are only now coming into operation. An interesting infra-red spectrometer of novel type, for study of the wave-length region 50μ–1 mm., was shown. This region is of particular importance in the theory of superconductors and of radiation from the Earth's atmosphere. A Michelson interferometer is used to scan the spectrum, the output intensity being received by a Golay cell. The resulting interferogram is then translated into a spectrum by digitizing the information and feeding to a computer. The instrument has considerable advantages over a conventional infra-red spectrometer in speed: in a typical example the range 100–300μ was observed in 25 min., with a resolution of 0·4 cm^{-1}, and computed in 5 min. It is hoped that with further development corresponding advantages in resolution will also be obtained.

The same Division also showed an ultrasonic goniometer In this device the critical angle of reflexion of an ultrasonic wave (5 mc /s) incident upon an area of about 1 cm^2 of the surface of the specimen is measured In metals of marked elastic anisotropy, any preferred orientation introduced during fabrication can be detected from the change in this critical angle It is, for example, in some cases possible to determine the rolling direction of a plate By varying the frequency of the incident wave (2–15 mc /s) some information on the depth of surface effects in texture can be obtained

In the Metallurgy Division results of importance in the fundamental theory of metals are being obtained from transmission electronmicrographs of thin iron foils Strip, 0 02 in thick and representative of bulk material, is thinned by electropolishing to 2–3000 A , at which thickness electrons can penetrate it The idea that in alpha iron two dislocations with <111> Burgers vectors unite to form one <100> dislocation with a saving of energy has been confirmed by the observation of a hexagonal network formed by the interaction of two dislocation systems Distortion in parts of this network, shown in some of the photographs exhibited, can also be explained in terms of the interaction of stranger dislocations Photographs were also shown of precipitates, about one hundred atoms thick, growing from a supersaturated alloy in dendritic form on dislocations

The recording of creep strain data is often a major item in the programme of a large metallurgical laboratory, and a new electrical recording extensometer, developed in the Division, promises to simplify this problem The movements of the extensometer are measured by the changes in inductance in a linear differential transformer fitted to the extensometer limbs The transducer is built into a bridge circuit, in which an electronic detector is used to determine the balance conditions, and measurements are independent of zero drift or changes in amplification Long-term stability, of great importance in tests lasting 10,000 hr or more, is dependent only on the stability of the transducer and resistors Other advantages of the equipment, the sensitivity of which is comparable with that of a mirror extensometer, are the possibility of measurements over a large range of strain without readjustment, and the application of automation to the recording of the data

Other Divisions of the Laboratory are concerned more with developments in applied science, with particular reference to problems of interest to industry, and Control Mechanisms and Electronics Division demonstrated a technique for the manufacture of radial coded plates for recording digitally the instantaneous position of a revolving shaft The individual code zones are generated circumferentially in succession, by optical reduction from a 35-mm film in conjunction with a dividing machine, and the precision of the latter is the limiting factor in the angular resolution obtained This process is much quicker, particularly for complicated code systems, than earlier methods of programming a set of events, for example, lamp flashes, to produce one element of all the code zones simultaneously in a radial direction An example was shown of an eighteen-code system with a resolution of 0 01° and a total radial width of 0 1 in

An application of radial diffraction gratings was shown in a system for measuring the torque in a rotating shaft Each end carried a radial grating in conjunction with a similar stationary grating, producing an alternating signal by interruption of an optical beam Any torque on the shaft is manifested as a phase difference between the signals from the two ends , such a system is sensitive to a few seconds of arc

In addition to the work on the use of diffraction gratings in machine-tool control, several novel uses of the interferometric principle were exhibited by the Light Division, a Kosters prism being used as a compact Michelson interferometer When used to measure the angle of tilt of a reflecting surface by the alignment of white light fringes such a system is sensitive to 1/10 sec of arc The instrument, with both coarse and fine adjustments to facilitate setting, has possible applications in engineering metrology The Kosters prism is also used as a reverse shearing interferometer for testing the revolution symmetry and asphericity of large mirrors In another method, in which no test plate or comparison system is needed, such larger systems are examined by the superposition of the scattered light from two identical plastic scattering screens The interference colours seen on the mirror indicate directly to a millionth of an inch how far each point of the surface is above or below that of an imaginary perfect sphere

The work of the Aerodynamics and Ship Divisions is from the nature of their subjects rather more specialized than that of other divisions Perhaps the field of greatest topical interest on display in Aerodynamics Division was that concerned with the new aerodynamic problems that occur in hypersonic flow (that is, at speeds greater than about five times that of sound), particularly those associated with the temperature of several thousand degrees centigrade that arise from aerodynamic heating The Division is developing a shock tunnel, in which the flow duration is about a millisecond, and a ‘hotshot’, in which about twenty times this flow duration can be obtained Two small shock tubes were shown in which spectrographic and microwave techniques are being developed for temperature measurements and for studying the effects of dissociation and ionization

Also of current interest is the design of slender wings, the planform and section shape of which combine to give the required low drag at cruising speeds of about twice the speed of sound, together with satisfactory stability characteristics and good landing and take-off performance Vortex-type flow separations from sharp edges are being studied in transonic

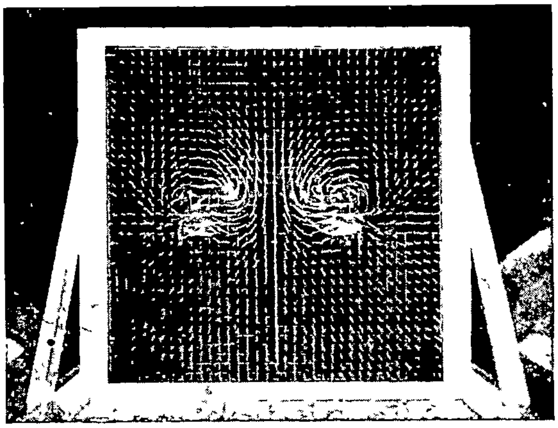

Fig 1 Vortex wake behind a swept-back wing at low speeds as shown by a tuft grid placed behind the model

and supersonic flow, and appear to behave in a remarkably similar way to those at low speeds (Fig 1) The work shown included detailed quantitative explorations in a low-speed tunnel and flow visualization experiments on a wing oscillating in a water tunnel in which qualitative observations were being made on the flow in these dynamic conditions

Results were also displayed from an extensive series of investigations into the aerodynamic design of swept wings for aircraft to cruise in the Mach number range 0 8–1 2 A special design of wing section has been developed to delay the drag rise that occurs at transonic speeds, and methods of combining a high drag-rise Mach number with a large drag-rise/buffet margin are being sought To enable drag-rise and buffet boundaries to be predicted, a semi-empirical theory has been developed for calculating pressure distributions in two-dimensional transonic flow The effects of wing planform, camber and twist have also been studied, together with the design of the junction between wing and fuselage, with the object of maintaining the full sweep of the isobars over the whole of the wing span One of the biggest problems is to reduce the required body 'waisting' to an amount acceptable for civil aircraft

Research displayed on boundary-layer and shear flows included theoretical and experimental investigations into the mechanics of transition following the non-linear growth of small disturbances, measurements of surface friction, and studies of turbulent boundary-layer development, wall jets, pipe flow, and the flow up an abrupt step at a Mach number of 2 5

As part of a long-term programme of research into ship vibration, the Ship Division demonstrated apparatus for determining the characteristics of the oscillatory pressure distribution around model propellers A large dynamometer for propellers up to 24 in in diameter measures torque and thrust electrically by movement of a balanced armature transformer, connected to a bearing in a helical slot on the shaft in one case, and to a flexible coupling allowing only axial movement in the other A new 12-in open dynamometer was also displayed this has a capacity of 5 lb /ft torque and 50 lb thrust at 0 to 2,000 r p m , torque being measured by balancing the reaction on the motor casing, and thrust by balancing the axial load on the shaft Both components are measured by dead-weight and spring systems, recording on a built-in chart recorder

On the Lithgow water tunnel, techniques for automatic data recording and analysis have been installed Measurements of the physical quantities are converted into either rotation of a shaft or into voltages shaft digitizers or digital voltmeters then turn these into coded electrical pulses suitable for feeding to computers

THE BRITISH GLASS INDUSTRY RESEARCH ASSOCIATION

NEW LABORATORIES

THE official opening of the newly built laboratories of the British Glass Industry Research Association by the Right Hon the Earl of Halifax, chancellor of the University of Sheffield, which took place on June 6, marked a noteworthy stage in the development of industrial research for the British glass industry Co-operative research has been continuously expanding since the inauguration by W E S Turner of a Department of Glass Manufacture in the University of Sheffield in the autumn of 1915 Prof Turner, then a lecturer in chemistry in the University, pioneered the establishment of a centre of organized scientific research into the physical and chemical properties of glass, to provide technical and scientific advice to the industry, and to include facilities for teaching Under his influence and professorship (he occupied the chair from its inauguration in 1920 until his retirement in 1945) the Department of Glass Technology, as it was renamed, became known and respected throughout the world by those interested in the manufacture and use of glass

In his early endeavour to found the Department of Glass Manufacture, Turner received great encouragement from his professor, the late W P Wynne, who loaned him a small chemical laboratory for his investigations and a tiny attic to house his glass-melting furnace He also received the enthusiastic support of glass manufacturers—particularly those of south Yorkshire and of Lancashire With increase of work and staff, Turner expanded his Department to occupy first a section of the applied science building of the University, and when this became insufficient, the site of a derelict glassworks in the Attercliffe district of the city The latter site was occupied until 1938 when, with the financial support of the glass industry, the present Department was built by addition to a large house occupying extensive grounds adjoining the main University territory

After the Second World War it became apparent that the requirements of industrial investigations, and that part of the research work which formed their immediate background, involved so much time that staff could not efficiently conduct them coincidentally with teaching and long-term research duties Prof H Moore, who succeeded Prof Turner on his retirement in 1945, therefore advocated the establishment of a research association as a separate entity, the function of which would be to attack the industrial and development problems, leaving the University Department free to concentrate upon fundamental research and the education of glass technologists On the retirement of Prof Moore in 1955 this plan was adopted, Prof R W Douglas being appointed to the chair of glass technology, and Dr R G Newton as director of the newly formed Research Association From this time until the occupation of its new building in January 1959, the Research Association's staff was successfully accommodated in the University Department's building, despite the rapid expansion of both organizations The foregoing will have indicated the close connexion between the University, the Research Association and the glass industry , the new buildings of the Research Association, built to the design of Prof Stephen Welsh, now stand adjacent to the University Department, which will enable the close connexions of the past to be maintained in the future

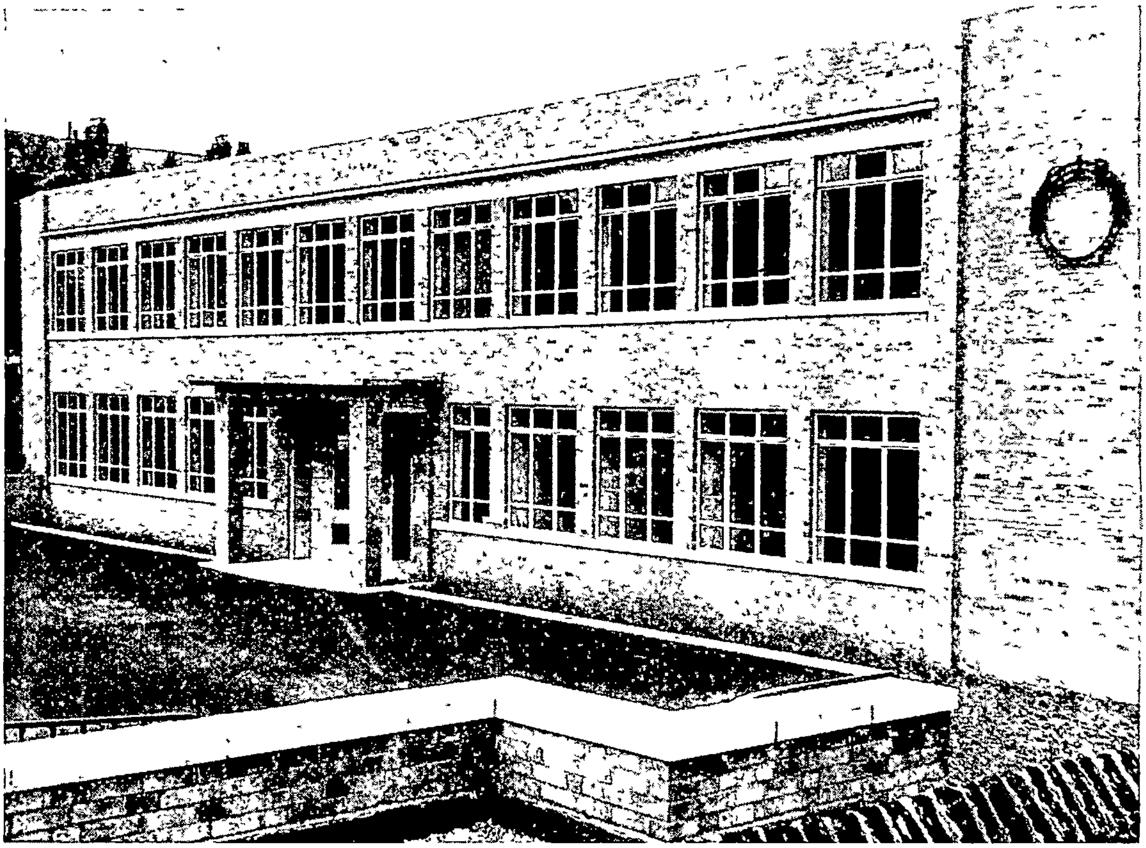

Fig. 1. The British Glass Industry Research Association Laboratories

The British Glass Industry Research Association is supported by eighty-nine subscribing member firms, forty-seven of which are engaged in glass melting, the remainder being closely associated with glass manufacture through the supply of raw materials or are connected with the manipulation of fabricated glass, as, for example, the formation of articles from glass tubing. The strong backing of the British Glass Industry Research Association by industry is denoted not only by the fact that approximately half its income is derived from members' subscriptions but also from the fact that the forty-seven members previously noted as being concerned with the actual melting of glass together melt 98 per cent of the total glass melted in the United Kingdom. Strong financial support is also provided to the Association by the Department of Scientific and Industrial Research.

Following the opening ceremony, members and guests of the Association were invited to tour the new building and inspect numerous exhibits which illustrated the type of work being carried out by the Research Association. The laboratories are sectionalized to conform so far as possible with the type of problem to be dealt with. The two-story building, which has a total superficial area of 20,000 sq. ft., is of 'L'-shaped plan, the ground-floor housing administrative offices, a section dealing with fuel, furnace and instrumentation problems, laboratories for the study of glass technological problems, a refractories section, and a furnace room with its associated batch mixing shop. The furnace room is sited at the extreme end of the wing and occupies a single story only so that heat and noise will not impede the work of other sections. The first floor is occupied by a reference library and information section, with associated reading rooms and meeting room, work study section, drawing office, and with the physical and chemical laboratories. Each of the latter two sections is subdivided into main and subsidiary laboratories. In the chemical section, for example, a separate division has been made to enable the durability of glass to various attacking media to be studied without the influence of the general atmosphere of the main chemical laboratory. Muffles and lead-lined fume cupboards for decomposition with hydrofluoric acid have also been segregated, and a separate division for spectrographic work has been provided.

A semi-basement extending beneath approximately half the ground-floor area contains an excellently equipped workshop, a pot room and a pot drying-room for the manufacture of small melting pots and other refractory articles. The remainder of the basement area is given to storage space, boiler-house, and a glass grinding, cutting and polishing unit.

Numerous demonstrations illustrating the type of work done by individual sections were presented, of which only a limited number may be mentioned within the compass of this short review. The fuel, furnace and instrumentation section demonstrated methods of surface temperature measurement and the estimating and recording of oxygen content of waste gas from furnaces, together with results of furnace heat surveys carried out at member-firms' factories with the view of assessing furnace performance under varying conditions. The physics section demonstrated laboratory apparatus for the determmination of tensile strength and thermal expansion, the latter by instrumental recording of the rate of expansion, thus eliminating the necessity for lengthy periods of direct observation. This section also demonstrated a pressure test rig for glass panels in which deflexions from fifty individual points on the glass surface were simultaneously displayed on scale instruments and cine-photographed at second intervals during the loading cycle. The performance of different types of refractory materials for glass furnace construction had been the subject of investigation by the refractories section, and a demonstration of a corrosion–erosion test rig was given. The glass technology section showed a novel rotating hearth furnace designed to give identical thermal treatment simultaneously to a number of experimental glass batch mixtures. This apparatus is to be used for study of the influence of raw materials on the rate of founding of glass. The chemical section, in addition to numerous examples of analytical techniques in silicate analysis, demonstrated apparatus for the determination of the durability of glass to aqueous attack, and gave an excellent demonstration of the analysis of gaseous inclusions in glass. The demonstration showed methods of extraction of minute bubbles of gas from solid glass and of their analysis to the component gases carbon dioxide, carbon monoxide, sulphur dioxide, sulphur trioxide and oxygen. Such studies have an important bearing on the problem of melting high-quality glass at maximum rate. The work-study section illustrated the use of one-second interval cine-photography for the study of manual operators in factories, and has shown that this technique can prove of value when a number of individual manual operations have to be co-ordinated with each other or with the operation of a machine.

Speakers at the official luncheon marking the opening ceremony reviewed the origin and future objectives of the British Glass Industry Research Association. Dr. L. H. A. Pilkington, chairman of the Council of the Association, directed attention to the man-power deployed on research in glass technology at the present time, estimating this to be some 200–250, and forecasting that the figure would increase to 750–900 within a five-year period. Although smaller in numbers than a force of some 750 at present employed in research by four of the largest glass manufacturing firms of the United States, these men managed to keep us abreast of developments in many fields and definitely ahead in some. Mr. A. W. Clark, chairman of the Glass Manufacturers' Federation, referred to the value of research associations to smaller firms the resources of which could not justify individual research units.

COIL SPRING FEDERATION RESEARCH ORGANISATION

NEW LABORATORIES

THE Coil Spring Federation Research Organisation, which has been in existence for fourteen years, has for the majority of this time confined its research activities to extra-mural work in universities, although the long-term aim of the spring industry has always been to operate its own research and development laboratories while maintaining the close links it has established with universities. This has now been achieved by the setting up of a new research centre, the construction of which has been financed from reserves set aside for the purpose.

The two-story laboratory block recently completed in Doncaster Street, Sheffield, is probably the most comprehensive of its kind for research into all forms of springs and spring materials.

The ground floor, in addition to the usual reception facilities, contains laboratories for heavy-fatigue testing, general mechanical testing, experimental heat treatment and electroplating. In the fatigue testing laboratory are housed 12½ h.p. machines capable of applying a dynamic load of 9 tons, which are used for fatigue testing heavy coil springs; up to eighteen springs may be tested at one time. Other machines used for fatigue testing springs of the internal combustion engine type are capable of infinitely variable speeds of compression of up to 4,000 per min. Fatigue tests in repeated torsion are carried out on torsion bars, and are used to produce data from which an assessment of the effects of composition, heat treatment and surface condition can be made prior to the manufacture of experimental helical springs. A special feature of this laboratory is the sound-proofing and anti-vibration features incorporated in both the suspended ceiling and the floor.

The mechanical testing laboratory houses a variety of conventional machines used for determining the properties of both specimens and springs, covering the range of material diameters 0·004–2·0 in. One machine, for example, is capable of developing a maximum torque of 120,000 in. lb., and is used to investigate the effects of hardenability on the static torsional properties of large-diameter spring steel bars.

Many researches relate to the load-deflexion characteristics of springs and the Organisation has a comprehensive range of machines, capable of applying static loads from a few ounces up to 30 tons. The determination of fatigue characteristics of drawn wires of diameters 0·01–0·25 in. is provided for by high-speed rotating-beam fatigue machines, which can complete up to 100 million cycles in as little time as one week. The study of corrosion and protection of spring materials and the effects of hydrogen embrittlement due to electroplating has had an important place in the Organisation's programme for many years. The work is being continued in a new laboratory specially fitted out for this purpose; the plant in it has been presented by Messrs. Canning, Ltd., the Birmingham manufacturers of electroplating equipment. Facilities are available for electroplating copper, zinc, tin, cadmium and nickel. The experimental heat-treatment laboratory is equipped with fully instrumented electric furnaces for general heat treatment, and high-temperature heat treatment under various types of protective atmosphere.

The laboratories contain a number of machine tools and a shot-peening unit which automatically rotates the object under treatment while at the same time traversing it with the shot stream It is being used in a fundamental study of the effects of shot-peening and optimization of it, together with an assessment of possible methods of measuring intensity

The first floor is devoted to light laboratories (containing small static testing machines, general scientific instruments and equipment), administrative offices, and a conference room The materials testing laboratory contains machines for determining macro-hardness, tensile and torsional properties of wires and load-deflexion characteristics of small springs Metallographic facilities are provided in specially fitted rooms for rough sample preparation, fine polishing and etching, microscopical examination and photography The microscope room contains a high-powered binocular bench microscope, projection microscope and micro-hardness testing equipment

The Organisation is studying spring materials for elevated temperature applications, in particular the stress-temperature relaxation properties of springs made from a very wide range of alloys A battery of spring creep testing machines is installed which will enable the behaviour of springs to be determined up to 850° C

CHEMISTRY OF PROPELLANTS

A MEETING was recently held in Paris (June 8–12) under the auspices of the Combustion and Propulsion Panel of the Advisory Group for Aeronautical Research and Development, with "Chemistry of Propellants" as the main topic It was felt that such a meeting could contribute to a useful exchange of research information and discussion of current problems among North Atlantic Treaty Organization countries Its importance can be judged by the attendance of nearly two hundred observers from eleven countries, nominated through their Advisory Group for Aeronautical Research and Development national delegates

The meeting was opened by Dr von Karman, who was supported by Dr Seitz, the science adviser to the North Atlantic Council, and his recent predecessor, Dr N F Ramsey Later in the week Dr G B Kistiakowsky, the new scientific adviser to the President of the United States, attended and took part in the proceedings These could be classified under three main headings, namely, propellants or associated features for liquid rockets, solid rockets and air-breathing engines, and the papers presented covered reviews of existing knowledge, reports of recent work and assessments of future problems

The first technical session was introduced by a paper by S Greenfield (United States), who reported on an experimental evaluation of liquid-propellant data This was based on a research programme to compare differences in behaviour of various hydrocarbon fuels when burned with liquid oxygen The fuels were pure samples of each of the chemical types such as paraffins, aromatics and olefins together with a reference fuel specified as *JP–5* The main results covered liquid film heat transfer coefficients and their variation with heat flux and combustion stability, specific impulse variations with mixture ratio, and effect of aromatics on available energy in fuel-rich gases suitable for turbo-pump operation An interesting feature of this work was the precise measurements achieved and the important influence of combustion chamber length (or L^*) on performance The conclusion was drawn that naphthenics are beneficial in a mixed fuel, but normal paraffins are of doubtful value

This paper was, to some extent, complementary to another by R J Thompson (United States) covering theoretical performance evaluation This work was carried out on an electronic data-processing machine and presented a vast tabulation of thermodynamic functions and propellant parameters which were discussed and illustrated The main propellant combination discussed was liquid oxygen and kerosene, although data on fluorine-liquid hydrogen were also used to illustrate the calculations Additionally, thermodynamic properties as functions of temperature for eleven of the more important elementary monatomic gases were given It is certain that these two papers will be of great use in future studies of propellants

The next paper in this group was by D L Armstrong (United States) and reviewed the characteristics of liquid propellants desired and achieved in rocket engines The important physical properties included vapour pressure, density, viscosity, specific heat, boiling and freezing points, and other features which were tabulated and discussed Chemical properties were also enumerated and mention was made of reactivity, self-ignition, combustion kinetics, stability and corrosion The author also gave some indication of performance, manufacturing processes and suggested propellants for various missions, but much more detailed and relevant papers on these aspects were presented by W G Parker and G Ruston (Great Britain) on the merits of utilizing high-energy propellants, and S H Dole and M A Margolis (United States) on the sources, availability and estimated cost of propellants The former took a slightly unusual line in dismissing the majority of the exotic propellants from consideration, first, because of the unfavourable properties such as extreme reactivity and toxicity, and secondly, because the advantages of higher specific impulse become less marked beyond values of about 320 sec Their conclusions were that liquid hydrogen was worth developing because of its probable use in nuclear rockets but it should be in combination with nitric acid or hydrogen peroxide rather than liquid oxygen The accidental combination of hydrogen and oxygen liquid or vapour could be too great a hazard to risk The paper on costs pointed out that prices of many propellants would be significantly altered if production demands increased, but even allowing for this, it was clear that the cryogenics would give a better performance than the storable liquids for a given cost Costs should, however, include the overall system cost and some curves were given showing flight vehicle cost against total impulse required for solid propellant storable and cryogenic At the higher values of total impulse, the cost of using these propellants was in descending order This was strongly challenged by protagonists of solid propellants during the discussion

The papers on solid propellants were given by R Steinberger (United States) on the properties o double-base forms with a corresponding one by P Tavernier and J Boisson (France) on composite forms and one on burning rate control by G H Young (Great Britain) All these appeared to suffer from the limitations imposed by 'security', but the first two gave useful accounts of the standard materials and processes in manufacture It was interesting to compare these and from this point of view they were an informative contribution Steinberger, however, included a good deal more on the life expectancy of double-base propellants This is not surprising in view of the much longer experience of them which exists The paper by Young covered some of the same ground and, rather than a discussion of burning rate control, was limited to descriptions of methods of measuring burning rate and the range of burning rates achieved The difficulties imposed on this author by the classified nature of his subject were obvious and it was generally agreed that it could only receive suitable treatment at a closed session

The papers on air-burning fuels included one on properties and preparation of ramjet fuels by M Barrere and G Français (France), one on performance evaluation by E Perchonok (United States), one on deposits in jet engines by R Breitwieser (United States) and a final one on physicochemical reactions during nozzle flow by J F Morris (United States) The first two covered the main features found necessary in the special conditions of ramjet operation and collected much data which will be useful for future reference Both papers dwelt on the use of solid fuels in slurry form and the attractions of boron hydrides and other compounds, but the American paper emphasized some additional considerations if ramjets are to be operated at hypersonic speeds For example, the need for regenerative cooling of engine walls will limit the use of *JP*–4 fuel to speeds of $M=6$ The high gas temperatures resulting from these speeds also have an important effect on dissociation conditions and thrust available With frozen gas exit flow, the thrust may be reduced as much as 58 per cent at $M=8$, compared with equilibrium flow This problem was treated by Morris, who reviewed the background of relaxation rate-theory and discussed the gaps in knowledge which will enable predictions of non-equilibrium flow of both internal and external gas for hypersonic vehicles The long list of references appended to this paper calls for special mention as it extends to more than four hundred The other paper in this group emphasized the problems of solid deposits in engines and pointed out that these became more serious with some of the high-energy fuels now being considered Boric oxide is one combustion product which may form on engine surfaces in large quantities Some measurements on convergent–divergent nozzles showed losses in total stream momentum of more than 5 per cent within 20 sec of initiating combustion Other sensitive components are turbine stator blades and combustion chambers Two mechanisms of deposition were discussed, consisting of diffusion of particles less than $\frac{1}{2}\mu$ diameter, and of impact by particles of 5μ and larger The former was analysed theoretically and compared with measured deposition rates Although good agreement was claimed, this analysis received some criticism during the discussion

In addition to the papers, a round table discussion on basic problems in propulsion was held with Dr von Karman in the chair The discussion was initiated by A D Baxter (Great Britain), who summarized the merits of liquid propellant rocket engines and outlined some of the remaining lines which require research These included physical problems such as heat transfer and combustion chamber design parameters, and chemical problems associated with propellant stability, ignition delays and reaction rates H W Ritchey (United States) then presented a similar case for solid propellants and was followed by three speakers giving views on futuristic possibilities G B Kistiakowsky (United States) spoke on solid propellant horizons, J W Bond (United States) on electromagnetic and nuclear thermal propulsion, and A Ferri (United States) on composite launchers The last was a stimulating argument in favour of air breathing engines as the first stage in multi-stage rocket vehicles One of the advantages would be the ability to fit aerodynamic lifting surfaces and fly the launcher back to the take-off point The discussion was so successful that it was continued at the final session of the meeting, ranging over a broad field Points brought out were the convergence of design features in solid- and liquid-propellant engines, the question as to how vital improved specific impulse was, the problems of size in rockets and the future of nuclear rockets

This discussion was a fitting climax to a successful meeting and no doubt, when the edited proceedings are published, they will be found to provide a valuable addition to the literature, not only because of the data included, but equally because of the excellent bibliographies attached to most papers A D Baxter

CLAY MINERALS

TWO series of meetings on clay minerals were held in Yorkshire during April The first, at Sheffield, was arranged by the Clay Minerals Group of the Mineralogical Society Two sessions on April 15, in the Metallurgy Department of the University, were devoted to the reading of scientific papers, while on April 16 visits were made to the works of Thomas Marshall at Loxley and General Refractories at Wharncliffe The chair at the scientific sessions was occupied by Dr A F Hallimond (London), chairman of the Group, in the morning, and by Prof J White (Sheffield) in the afternoon

Several papers concerned the industrial application of clay mineralogy In the first of these, E H Steger (London) discussed various problems in civil engineering in which clays are implicated, and dealt particularly with soil stabilization by injection of a suitable clay suspension into sands, etc The factors necessary to give good results are broadly known, but much work on fundamental aspects is still required In the discussion, the difficulty of replicating laboratory findings in the field was widely referred to

Divergent views upon the relationship between the mineralogical constitution and the firing properties of clays were expressed by Prof G W Brindley and S Udagawa (Pennsylvania) and by Dr R W Nurse (Watford) The former described how, by 'synthesizing' clays from mixtures of appropriate pure minerals over a range of compositions, it is possible to make some forecasts regarding the behaviour of natural clays from a rapid check of their mineralogical composition This technique enables immediate rejection of completely unsuitable clays, but those which appear of possible use still have to be tested individually Dr Nurse, on the other hand, could find no correlation between firing properties and mineralogical composition for a series of clays of various geological ages

The use of thermal expansion measurements in indicating the mineralogy of clays[1] was considered by D A Holdridge (Stoke-on-Trent), who showed its application in quartz determinations The significance of the same test after firing was also discussed

Dr R F Youell (Leeds) described how X-ray data on heat-treated silicates, which he had obtained earlier, were explicable on the basis of silicon-containing spinel structures[2] He particularly referred to the composition of the spinel phases and the occurrence of ordered transformations In discussion, the propriety of using the term 'silicate' for a silicon-containing spinel was questioned and the frequency of occurrence of ordered transformations was stressed

Three general papers were also read In the first B D Mitchell and Dr R C Mackenzie (Aberdeen) described a relatively inexpensive controlled-atmosphere differential thermal analysis apparatus and illustrated its applicability to investigations in nitrogen, oxygen and steam, while in the other two Dr H G Midgley (Watford)—this paper was read in his absence by Dr R W Nurse—and W Windle and E K Cundy (St Austell) described occurrences of sepiolite and zinnwaldite, respectively, in Cornwall, chemical, X-ray and other data were given

This meeting not only brought to notice relatively new uses of clays in industry (such as their use in soil stabilization) but also raised the practical question of the value of mineralogical analysis in assessing clays Difficulties encountered in relating the mineralogy of a clay to its firing properties could, for example, be due either to incomplete mineralogical data or to effects being not truly additive the observations reported rather suggest the latter

The Sheffield meeting was followed by one at Leeds during April 17–18 arranged by the X-ray analysis Group of the Institute of Physics This meeting included a session on clay minerals as well as one on biological fibres, only the former is reported here

No outstanding advance in structural investigations of the common natural clay minerals was forthcoming at the meeting Prof G W Brindley, in an introductory address, pointed to the value of electron diffraction techniques in such investigations He was able to report a very promising approach to the problem of thermal changes in kaolinite by his collaborator, M Nakahira, using small single crystals This work suggests that the 'spinel' phase is really a silica–alumina crystallization structurally similar to spinel[2], and appears to have furnished clear evidence that the much-discussed metakaolin is not amorphous, but is an intermediate stage in the formation of spinel, having a substantial degree of crystallinity

The dehydration products of kaolinite were also discussed by F Vaughan (Stoke-on-Trent) D A Holdridge showed the possibilities of thermal expansion measurements for studying phase changes on firing Quartz content, notably, can be estimated by this means

Interesting structural studies on scarbroite were reported by Dr J Goodyear and Dr W J Duffin (Sheffield) and on iddingsite by G Brown and Dr I Stephen (Harpenden) H P Rooksby (Wembley) reported on further detailed work on iron and aluminium oxides

The question of surface structure in clays is one of fundamental importance, about which there is still much uncertainty An extensive, many-sided approach to this problem is being made by Prof J J Fripiat and collaborators in Belgium under the auspices of Institut National pour l'Études Agronomiques du Congo Belge Among the techniques under study are measurement of surface hydroxyl groups by exchange with heavy water vapour, and methylation and acetylation for determining acidic groups

Dr D M C MacEwan (Dundee) reported on an extensive series of calculations on diffraction effects from mixed-layer structures, now being carried out with electronic calculators The resulting curves will be published as a special monograph by the Spanish Consejo Superior de Investigaciones Cientificas

Study of a German 'fireclay mineral' by Prof A L Roberts and Dr W E Worrall (Leeds) provided further support for Schofield's theory of the existence of isomorphous substitution in kaolins

R C MACKENZIE
D M C MACEWAN

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[1] cf Brough, J , and Robertson, R H S , *Clay Min Bull* , 3, 221 (1958)

[2] Steadman, R , and Youell, R F , *Nature*, 180, 1066 (1957) Brindley, G W , and Nakahira, M , *Nature*, 181, 1333 (1958)

THE COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

THE second report of the Council for Scientific and Industrial Research covers the year 1958 in which the Department's gross expenditure was £9,453,652, compared with £8,255,561 in the previous year, and reduced to £8,357,913 by various receipts (£464,713 being from the National Physical Laboratory) for work done for Government departments or for industry, the net increase on 1957 being £1,108,070 Grants to students amounted to £444,958, the number of students in training being 1,681 and in 1957, 1,301, of whom 781 in 1958 and 653 in 1957 were new The advanced course studentships increased from 152 in 1957 to 201, of which 184 were new, and of 26 research fellowships (18 in 1957), 14 were new Grants for special researches totalled £475,754, numbering 239 compared with £363,884 and 193 in 1957, and of these 147 were new Of these grants 106 were in physics, 45 in chemistry, 32 in biology and biochemistry, 24 in other engineering, 11 in geology, 7 in mathematics, 6 in chemical engineering and metallurgy, and 3 in electrical engineering Chemistry claimed 593 of research students, physics 360, biology and biochemistry 208, mathematics 144, chemical engineering and metallurgy 110, other engineering 100, geology 99, electrical engineering 50, and human sciences 17

Expenditure on the National Chemical Laboratory decreased slightly, from £160,404 in 1957 to £155,010, and there were also slight decreases in expenditure on fuel research (£330,502–£326,899) and fire research (£38,745–£37,174) , but with these exceptions expenditure increased on all branches of the Department's work, the biggest increases being in road research (£560,813 compared with £441,762 in 1957), the National Physical Laboratory (£737,958 compared with £638,031), headquarters administration (£377,905 compared with £307,436), mechanical engineering research (£507,104 compared with £454,810) and the Geological Survey and Museum (£328,329 compared with £282,370) Expenditure for other sections in 1958 was as follows, the 1957 figures being given in brackets building research, £541,371 (£521,065) , forest products research, £135,645 (£128,256) , hydraulics research, £100,650 (£91,967) , pest infestation, £89,369 (£83,341) , radio research, £159,398 (£135,657) , and water pollution research, £103,882 (£90,020) Besides the National Physical Laboratory, considerable payments for work done for other Government departments and industry were received in respect of fire research (£143,330), the National Chemical Laboratory (£104,715), the Geological Survey and Museum (£97,527), road research (£59,182), hydraulics research (£44,710), building research (£33,879) and mechanical engineering research Contributions to European nuclear research increased from £930,000 to £1,100,000, and of the grants for special researches authorized during the session October 1, 1957, to September 30, 1958, by far the largest is the £355,000 over four years from January 1, 1958, to Prof C C Butler of the Imperial College of Science and Technology for the construction of a large liquid-hydrogen bubble chamber

ROTHAMSTED EXPERIMENTAL STATION

REPORT FOR 1958

THE report of the Rothamsted Experimental Station for 1958* is a book of 283 pages containing accounts of the work of some twenty separate departments It follows the pattern of previous years in that it is introduced by a general report by the Director in which the more interesting departmental results are commented upon This is particularly valuable in that it enables the reader to appreciate something of the scope and cohesion of the Rothamsted work, and those who frame the Station policy are to be commended on the blend of science and practice that characterizes the research programmes Their reward is the use made of their results in the practical world of farming in Britain and overseas

The Chemistry Department has studied the action of organic matter in the soil, and popular conceptions of this may have to be somewhat modified in that in heavy soil, as at Rothamsted, its beneficial action appears to be derived solely from its nutrient content and no measurable effect from physical sources was found By contrast, in lighter soils organic matter is apparently necessary to maintain structure Work has continued on the main plant nutrients in soil and, in particular, attempts are being made to evolve a more accurate method of assessing available phosphate Soil analysts would welcome progress in this matter

The Physics Department has studied the electrical charges on clay, soil aeration, soil water, and the effect of crop rotation on soil structure This last experiment showed that using beet and carrots as the test crops, the effect from modification of structure due to rotation was largely confined to the period during, and immediately following, seed germination This again may surprise practical growers Studies in agricultural meteorology have continued and progress has been made with the analysis of temperature, humidity and ventilation data in spring wheat collected during the three summers 1955–57 A detailed survey is promised in a later report The mineralogical studies of the Pedology Department have been continued on native and foreign soils, and the results, as they accumulate, may well lead to a sounder basis for soil classification

Microbiological investigations have dealt with the decomposition of cellulose and some of the newer chemicals used in agriculture Many of these have proved to be subject to attack and therefore will be removed from the soil in time, a point of considerable practical importance Aspects of nodule formation on legumes have also received attention Although it has long been known that nitrate at the concentrations usually employed in nutritional work will depress nodulation, it was found that as little as 2 5 p p m of nitrate nitrogen would delay nodulation of white clover by two days A similar effect was given by nitrite but not by ammonium salts, asparagine, or urea, all of which are assimilated by the host plant at about the same rate

The Botany Department at Rothamsted has been interested for some time in the development and use of methods of growth analysis and these are now producing information on various aspects of crop growth Gibberellic acid was found to increase the yield of potatoes in the year under review This effect was only observed when nitrogen was high, and spraying actually reduced yields when this element was low Additional data suggest that the effectiveness of gibberellic acid depends also upon the time and frequency of application Weed studies reported upon include an evaluation of competition effects between crop and weed plants and the possible excretion of toxic substances by *Agropyron repens* No evidence of this was found in living material , the leachate from water cultures of this grass, in fact, actually increased the dry weight and leaf area of tomato and kale plants

The blackening of potatoes on boiling was the subject of a biochemical study that supported the belief that this discoloration is due to a complex of ferric iron and dihydroxy-phenols Boiling is believed to liberate ferrous iron, which combines with the dihydroxy-phenols in the potato to give relatively colourless ferrous complexes which blacken when oxidized in the air to ferric complexes Other work in this Department concerned mitochondria, the enzymic breakdown of chlorophyll in plant tissues and the properties, particularly the infectivity, of tobacco mosaic virus fragments

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* Rothamsted Experimental Station Report for 1958 Pp 283 (Harpenden Rothamsted Experimental Station, 1959) 10s

Research in plant pathology covers a wide field. Progress has been made in devising staining methods for preparations of plant viruses for electron microscopy at high resolution. This is new work, but enough progress has been made to encourage the hope that the methods will contribute usefully to the further elucidation of particle structure. The increasing importance of cereal viruses in agriculture adds to their interest, and useful information on infectivity and host ranges has been obtained. Experiments on initial field establishment of potato blight (*Phytophthora infestans*) have shown that this may occur without the normal stem-infecting stage. It is likely, however, that infection from contaminated soil can only occur in a wet season such as 1958. Trials on the susceptibility to wilt (*Fusarium oxysporum f. pisi*) of pea varieties commonly grown in Britain have shown that resistance exists, but the parasite itself is so variable that the breeding of resistant varieties will not be easy.

The Nematology Department has conducted studies on the changes in eelworm populations under different rotations and individual crops. These together with concurrent observations on the movement of eelworms in soil and over plants should interest those concerned with the control of these pests in the field. Frit flies, gall midges, wheat bulb fly, slugs and earthworms are included in the wide range of animals studied by the Entomology Department. A short section deals with the ecology of the natural enemies of aphids. The Bee Department, as a result of improved methods of assay, has learned more of the nature and function of 'queen substance' produced in the mandibular glands of queen honey bees. It has been shown that 'queen substance' contains an inhibitor which, when fed to queen honey bees, can prevent them from queen rearing and which can also inhibit ovary development in queenless worker honey bees.

As a result of the disastrous epidemic of virus yellows of sugar beet in 1957, the staff of the Dunholme Field Station organized a survey of crops and issued spray warnings when needed. As a result, 100,000 acres were sprayed with very satisfactory results when compared with unsprayed areas in September. The value of spraying against aphids to check the spread of virus yellows is now firmly established.

This account has necessarily omitted much worthy of mention, but it is impossible, in a short review, to do justice to all the work described in this report and the selection of items for particular mention here is obviously open to criticism. The extremely useful list of publications for the year 1958, each with an abstract of the contents, with which the report closes, is a fitting indication of the value of Rothamsted to biology and agriculture alike.

J. H. WESTERN

AUSTRALIAN DEFENCE STANDARDS LABORATORIES REPORT, 1957

THE main sections of the annual report of the Australian Defence Standards Laboratories for the year ended June 30, 1957 (Pp. iv+60. Maribyrnong, Victoria: Defence Standards Laboratories, Department of Supply, 1959), are devoted to a statement of the functions of, and scope of work undertaken by, the Laboratories and descriptions of some of the more important projects and investigations carried out by the Divisions of Chemistry, Metallurgy and Physics.

In the Metallurgy Division work has continued on the production and investigation of chromium-base high-temperature alloys. The ultimate aim is to develop alloys suitable for use in gas turbines operating at rotor blade temperatures of 950° C. or higher. The plant for the production of pure chromium has operated satisfactorily and a total of 475 lb. of metal was produced during the year. It has been shown that ductile chromium can be made from suitably pure electrolytic chromium. Investigations included experiments on the tensile properties of annealed chromium, the influence of pre-strain on ductility, precipitation hardening effects and creep behaviour. A fractographic study, augmented by X-ray diffraction tests, was made of the cleavage surfaces in cast chromium. In addition, work has been done on titanium alloys; cathodic protection of ships and naval structures; and the mechanism of polishing and the nature of mechanically polished metal surfaces.

The activities of the Physics Division are discussed under the headings of chemical physics; radiological physics; the development and testing of electrical and electronic components for use by the armed services; and metrology. The study by the microwave interferometric technique of the propagation of detonation has been most fruitful. Radiation alarm systems and other safeguards against the mishandling of radioactive sources have been developed and work has continued on the determination of the energy and angular distributions of the radiation intensity in air at various distances from a point radioactive source. Facilities for the precise calibration of end standards of length have been improved, and standardizations of lengths up to 40 in. based on the wave-length of light can now be made. A technique has been developed for determining the mean diameters of capillary tubes by the mercury content method to an accuracy of 0.00004 in.

The Chemistry Division has been active in a variety of fields, including the determination of gases in metals and alloys; the microdetermination of silicon; infra-red spectroscopy; adsorption; and organic and polymer chemistry.

The annual report lists the various personnel of the Laboratories and their status, and gives details of the publications by members of the staff during the year under review. Papers were presented by members of the staff to the thirty-second meeting of the Australian and New Zealand Association for the Advancement of Science held at Dunedin during January 1957 and to the Institute of Physics Conference on Contemporary Optics in Sydney during September 1956. Noteworthy visitors to the Laboratories during the year were Sir Owen Wansbrough-Jones, chief scientist of the British Ministry of Supply, and Sir Leslie Martin, chairman of the Australian Defence Research and Development Policy Committee.

THE IMPERIAL CANCER RESEARCH FUND

THE fifty-sixth annual report of the Imperial Cancer Research Fund*, for 1957–58, describes the lines of investigation in progress in the laboratories at Mill Hill and Lincoln's Inn Fields They can be sub-divided as follows

(1) *Tumours induced by viruses*

Work continues on the virus ætiology of cancer by studying the mechanism whereby the virus gains access to the cell it infects, the virus's mode of replication and its specificity Attempts are being made to grow the mouse leukæmia-inducing virus in tissue cultures of embryo fibroblasts, and by reciprocal transplantation experiments to find "whether the cellular elements in such transplants survive or whether virus is liberated to produce a new tumour by infection of the host's own cells"

(2) *Tissue culture studies of tumour cells*

The reaction of tumour cells to environmental changes is being studied by observing the effect of variation in the tension of carbon dioxide on cells of the mouse sarcoma 37

"The activities of individual cells in culture of the various mouse tumours are being examined by time-lapse cinematography *BP*/8C and *BAS*/56 ascites tumour cells show 'tails' which may attach to the glass and which have great tensile strength and elasticity The undulating surface membranes of these cells show very active pinocytosis and unusually large volumes of culture medium may be injected in this way "

(3) *Preservation of tumours in the frozen state*

"The frozen tumour bank preserves tumours in an unaltered genetic state and these can therefore be used to check the respective inbred strains of mice for any genetic divergence which affects histocompatibility In this way it has been shown, with a strain *A* specific tumour, not only that A_2G mice are genetically distinct from true *A* but that the genetic change occurred prior to 1952 "

(4) *Heterotransplantation of human tumours*

Human sarcoma tissue is being maintained by subcutaneous, intramuscular or intraperitoneal transplantation in cortisone-treated hamsters, subcutaneously in cortisone-treated mice and in the anterior chamber of the eye in normal guinea pigs The attempts to grow human lung cancer in guinea pig anterior chamber or in organ cultures were unsuccessful, but 25 per cent of human embryonic lung tissue grafts survived 22–49 days in mice treated with cortisone

Other human embryonic tissues such as bone and bowel, some human adult tissue, for example, skin and transitional epithelium, and human prostatic carcinoma and adult rodent lung and prostate have all been maintained in fluid media "Organ cultures of mouse prostate have been employed to study the direct action of œstrogens and androgens on glands from mice of different ages The œstrogens produced epithelial atrophy and testosterone a stimulation "

(5) *Hormone-dependent breast cancer*

About 50 per cent of human breast cancers cease to proliferate if they are totally deprived of the hormones which control cell multiplication in the normal breast At present the operative technique of cutting off the supply of hormones is by the surgical removal of the ovaries, both adrenals and the pituitary This somewhat drastic treatment may give spectacular growth regression and clinical improvement, but unfortunately these have proved to be temporary

(6) *A pregnancy-dependent mouse tumour*

The spontaneous mammary tumour BR6 has the peculiarity of always first appearing during pregnancy and mostly regressing after parturition The tumour incidence is very high (in excess of 97 per cent in more than 400 mice that lived longer than six months, had more than two litters, and where the mothers had developed tumours) Under certain conditions some females not only remain tumour-free but give rise to tumour-free sub-lines which "   appear from transplantation experiments, to be genetically different from the tumour-prone line and one aspect of this genetic difference may be a greater androgen production by the males of the tumour-prone lines"

I HIEGER

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* Imperial Cancer Research Fund Fifty-sixth Annual Report, 1957–1958 Pp. 39 (London Imperial Cancer Research Fund, 1959)

BEHAVIOUR OF SEA URCHINS

MANY of the habits of sea urchins were observed by A N Sinclair, during day and night diving in the waters around Sydney with members of the Underwater Research Group of New South Wales An aqualung and a waterproof torch were used (*Austral Mus Mag* , 13, No 1 , March 15, 1959)

When diving in daylight Sinclair was impressed by the numbers of the large, rough-spined sea urchin *Centrostephanus rodgersii* Many of these were seen in hollows carved in the sandstone rocks, and often the hollows were deep enough to contain the whole urchin, but were never as deep, comparatively, as the sharply etched hollows carved by the smaller urchins, *Heliocidaris erythrogramma* Other urchins appeared to be motionless, with the spines sticking out at right angles to the body surface in a typical 'hedgehog', or defence, position

It was found that after darkness set in the urchins became active Within an hour or two of sunset, numbers of *Centrostephanus* were seen 'out walking' on the rocks but they did not seem to favour walking on the sand The spines at such times were generally arranged in groups or cones If a torch was shone on the urchin for a short time no reaction to the light could be observed, but if the urchin was touched it immediately assumed the 'hedgehog' position seen in daylight

Results of marking specimens of *C rodgersii* in Clovelly Bay, Sydney, had shown that the urchins moved up to 3 or 4 ft from their rock holes within two hours of sunset and returned to their own holes by the next morning, though often each was lying turned round from its original position.

During daylight it was common to see vacant rock holes, which, by the absence of weed growth, appeared to have been recently vacated. Usually, however, these holes were again occupied within a week, but tagging techniques had been inadequate to reveal whether the occupants were the original ones or newcomers.

Unlike most of the finer-spined urchins, the slate pencil urchin, *Phyllasanthus parvispinus*, appeared not to live in holes, preferring crevices between rocks. In more than 200 sightings of these urchins, only one had been seen in a spherical rock hole. Most were in crevices, during daylight, but were so securely wedged in that they could only be moved by breaking spines. Other haunts of the slate pencil urchin were on the floor of forests of weed or kelp. Like *C. rodgersii* these urchins seemed to prefer deeper water and were more numerous in 20–30 ft. of water. Although each slate pencil urchin did not have its own particular rock hole, it returned to a particular locality.

The slate pencil urchins went out 'walking' at night, often covering 1 ft. in 20 min., and were seen attacking whelks bigger than themselves.

The commonest urchin at shallow levels within about 6 ft. of the surface was *Heliocidaris erythrogramma*. This was the dominant species, and practically the only urchin present in the intertidal zone. It lived in crevices and holes in the rock, which could be almost honeycombed. It appeared to dig holes much deeper in relation to its size than any other species. This urchin appeared in many colours: greens, reds, browns and purples, a new one being revealed at almost every dive. The spines were smooth and relatively short. One of the most interesting combinations of spine shape and colour in this urchin was in the blue or mauve specimens.

Tripneustes gratilla, a wanderer from tropic seas, apparently had the distinctive habit of being unconcerned with the need for shelter. It was usually found on the walls of caves or in the open many yards from the nearest shelter. It was a large-bodied urchin with very short white spines tipped red or mauve. The rounded body had a plain darkish colour, or was white with five darker major bands and five secondary bands. Some of these urchins carried small pieces of shell or weed, presumably for sheltering from the light. *T. gratilla* was usually seen at depths of 10 ft. or more.

Most of the useful observations made by diving were of an ecological, rather than a systematic, nature, and an observation ledge had been carefully watched at frequent intervals during the past seven months; however, other observation points will be established after a twelve months period has been completed. A handicap to observation was that many local residents had developed a taste for eating sea urchins and the colony risked extinction.

In summer the colony comprised: twenty *C. rodgersii*, one *H. tuberculata*, and one *P. parvispinus*. By early July the numbers of *C. rodgersii* had fallen to fourteen, and later in the month had been reduced to ten.

JOURNAL OF APPLIED POLYMER SCIENCE

THE study of polymeric systems originated largely from technological considerations, but has now grown into a scientific subject in its own right, with its own techniques and outlook. This change has occurred in a very short time, and its rate of growth can be illustrated by the increasing size of the *Journal of Polymer Science*, which attracts contributions from both chemists and physicists interested in the preparation and properties of these interesting materials. From the original *Polymer Bulletin*, published in 1945 with 158 pages, it has progressed stepwise: 1946–50, 598 to 800 pages; 1951–54, 1460 to 1,864 pages; 1955–57, 2,432 to 2,420 pages; 1958, 4,256 pages. This seven-fold increase in thirteen years shows no sign of slowing down, and the publishers have therefore decided, as a transition measure, to split the journal, the original journal to continue, but in addition to publish the *Journal of Applied Polymer Science**. The latter is intended to deal with the properties of industrially significant materials, leaving articles of a definitely basic character to the original *Journal*.

It is difficult to see how this distinction can be maintained. The first number of the *Journal* includes papers on such basic matters as thermal expansion and transition temperatures, impact strength and spherulite growth, and anisotropic properties of strained visco-elastic fluids. Perhaps a better grouping of subject-matter would be—preparative techniques; physical properties; characterization and constants; and applications.

The present tendency for publication of specialist journals, as distinct from the journals of learned societies of wider scope, must be taken as an inevitable consequence of increased specialization. Although it may facilitate the task of the scientist wishing to keep together papers on his own research subject, it has made it almost impossible for him to pay for the subscriptions. The stage has been reached where even the smaller scientific libraries cannot hope to purchase more than a small fraction of these specialist journals. This situation is likely to worsen, and the research man will have to visit large central libraries, or rely on abstracts to track down new papers of interest to him. Perhaps one solution is for the smaller libraries to pool some of their resources on a local basis, by arranging regular circulation through several laboratories. In any event one would like to see an extension of the system of reduced rates for personal copies. The increased cost cannot be blamed on the publisher; the cost per page has remained constant at 2.5 cents since 1952. The new *Journal* is somewhat larger in page size than the earlier publication, and this has improved the presentation and layout.

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* *Journal of Applied Polymer Science*, Vol. 1, No. 1, January–February, 1959. Pp. 127. Published bi-monthly, covering two volumes annually. Subscription price, 17.50 dollars per volume. (New York and London: Interscience Publishers, Inc., 1959.)

MEASUREMENT OF COSMIC NOISE AT LOW FREQUENCIES ABOVE THE IONOSPHERE

By J P I TYAS, C A FRANKLIN and A R MOLOZZI
Defence Research Telecommunications Establishment, Ottawa

THE Canadian Defence Research Board, in co-operation with the National Aeronautics and Space Administration, is at present designing a 2–15 Mc /s swept-frequency ionosphere sounder to be launched as an Earth satellite by a United States vehicle The preliminary design objective calls for operation over a one-year period in an elliptical orbit with a perigee and apogee of 300 and 1,200 miles, respectively Power will be derived from the Sun via solar cells and nickel–cadmium rechargeable batteries

System studies have shown that cosmic noise is likely to be an important factor in determining the minimum sounding power for a satisfactory signal to noise ratio Published figures for cosmic noise at 3 Mc /s give brightness temperatures varying between 7×10^6 °K [1] and 120×10^6 °K [2,3] Measurements on the Earth's surface, particularly at such low frequencies, inevitably involve assumptions concerning transmission losses through the ionosphere, and for frequencies less than approximately 15 Mc /s the accuracy of existing data on cosmic noise is questionable[4,5]. A direct measurement of this noise using either a rocket or satellite is therefore indicated, and the results obtained would have the added merit of being of considerable interest in the field of radio astronomy

Ground-based radiometers have been described by several authors[6,7], and design techniques appropriate to the ground environment are by now well established By comparison, a radiometer for use in a sounding rocket or a satellite is severely limited in its dimensions, weight, and power consumption In addition, it must also survive the mechanical and thermal shocks associated with a rapid ascent through the Earth's atmosphere

It is found that the successful instrumentation of such a radiometer depends critically on the design of a suitable low-frequency aerial and reference noise source The use of one or more Hertzian dipoles, on a space vehicle, poses a formidable aerial calibration problem, which becomes increasingly serious as the frequency is reduced This approach was therefore abandoned in favour of the magnetic dipole, which is easier to calibrate since it is relatively unaffected by the proximity of the ground or other conducting surfaces

Optimum utilization of a given volume of ferrite has been investigated, and it is of interest to consider the design and efficiency of a pair of loop aerials at 3 Mc /s using 300 gm of ferrite

Two 18 cm × 3 cm × 1 cm rectangular cores, each made up of three plates of ferrite, were space wound so that each winding covered 80 per cent of the length of its ferrite core The calculated radiation resistance of each aerial was

$$4 \times 10^{-4}\ \Omega$$

and was found to be negligibly small compared with the equivalent series resistance due to core and copper losses

For a bandwidth of 80 kc /sec , and with the two aerials connected in series, the power available at the input terminals of the receiver is

$$4E^2 \times 10^{-16} \text{ watts}$$

where E is in μV /metre This power is 39 db below that available from a matched, loss-less, half-wave dipole

Transistor receivers with equivalent input noise temperatures of 600° K at 3 Mc /s have been constructed, and if the brightness temperature of the cosmic noise is 120×10^6 °K , the signal to noise ratio at the receiver output will be 11 db This includes an additional aerial loss of 3 db due to the random polarization of the noise

Errors due to changes in the gain and band-width of the receiver are reduced by continuously switching the receiver input between the aerials and a reference noise source At the output terminals of the receiver the ratio of the switched power-levels is

$$\frac{G(P_N + P_{N1})}{GP_{N2}} = \frac{P_N + P_{N1}}{P_{N2}}$$

and is independent of the receiver gain (P_N is the noise power from the aerials , P_{N1} is the equivalent input noise power due to the receiver when connected to the aerials , P_{N2} is the input noise power due to the receiver and reference noise source when the aerials are disconnected , and G is the power gain of the receiver) The addition of an A G C loop increases the dynamic range of the receiver to approximately 50 db and converts the output into a voltage suitable for telemetering to the ground If the A G C time constant is short compared with the period of rotation of the rocket or satellite, the existence of directional properties in the cosmic noise may be observed

The overall accuracy of the instrument depends largely on the stability of the reference noise-level and the accuracy with which the aerials can be calibrated on the ground An avalanche diode is used as a reference noise source and its case temperature is monitored on a separate telemetry channel Laboratory tests on this radiometer indicate an overall probable error of less than ± 2 db in the measured cosmic noise intensity

Errors due to atmospheric and man-made interference (including radiation from ground-based transmitters) will be negligible at frequencies less than the minimum penetration frequency of the F_2 layer Since the radiometer will be operating in an ionized medium, the electron density in its immediate vicinity will set a lower limit to the frequency at which cosmic noise can be measured In practice, this low-frequency cut-off will be modified by the Earth's magnetic field, and may also be higher than the local plasma frequency if regions of increased electron density exist above the radiometer At very high altitudes it is possible that the Van Allen belts may play a significant part in filtering out the low-frequency end of the cosmic noise spectrum.

A prototype radiometer is undergoing vehicle acceptance tests and the final instrument is expected to make the first measurements of cosmic noise above the ionosphere at 3 Mc /s in the near future

The sensitivity and accuracy of the radiometer could be improved by having a controllable noise source and using the receiver as a null detector, a technique widely used on the ground A silicon diode operating in the avalanche mode generates noise, the level of which can be controlled by varying the direct current flowing through the diode[8] Thus, one has a semiconductor analogue of a temperature-limited diode, and radiometers of the type described by Ryle[9] become practicable for space vehicles

The experiment will be extended at a later date to observe changes in the cosmic noise-level with frequency using a swept-frequency receiver By observing the wave-length at which the noise-level starts to increase rapidly, plasma frequencies, and therefore electron densities, can be deduced at various heights over different parts of the world from a satellite travelling in an elliptical orbit

[1] National Bureau of Standards Circular No 557 (1955)
[2] Reber, G , and Ellis, G R , *J Geophys Res* , 61, 1, 1 (1956)
[3] Reber, G , *J Geophys Res* , 63, 109 (1958)
[4] Roman, Dr N , N A S A , Washington (private communication)
[5] Getmantsev, G G , Ginzburg, V L , and Schklovskii, I S , *U F N* , 66, No 2, 157 (1958)
[6] Dicke, R H , *Rev Sci Instr* , 17, 263 (1946)
[7] Ryle, M , *Proc Roy Soc* , A, 211, 351 (1952)
[8] Champlin, K S , *J App Phys* , 30, 7, 1039 (1959)
[9] Ryle, M , and Vonberg, D D , *Proc Roy Soc* , A, 193, 98 (1948)

SURFACE TOPOGRAPHY OF THE ANTARCTIC ICE SHEET

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IT has been reported by Lister and by Pratt[1,2] that the surface of the Antarctic ice sheet over much of the route of the Trans-Antarctic Expedition consists of a series of undulations with wave-lengths of 5–30 km and a mean amplitude of about 20 m In this respect the surface differs markedly from that of the Greenland ice sheet which, except near the margins is generally much more uniform[2,3] The question then arises as to whether the undulations seen in Antarctica are due to some effect of wind, which causes the snow to accumulate preferentially in certain places, or whether they are the result of unevenness in the rock bed upon which the ice sheet lies The following analysis leads to the conclusion that the latter explanation is the right one, and that we may hope to discover much about the topography of the bed simply by an inspection of the surface

Owing to the higher temperature of the lower layers of ice, and the large effect of temperature on the creep-rate of ice, the outward motion of the ice sheet probably takes place almost entirely by sliding on the rock bed (combined with rapid shearing in a very thin layer at the bottom)[4] The velocity of sliding u will depend on the shear stress τ at the interface, the effective roughness of the bed, and the temperature (and possibly on the hydrostatic pressure) At a given place on the bed let us assume that

$$u = \left(\frac{\tau}{A}\right)^m \tag{1}$$

where A and m are constants According to Weertman's calculation[5], which is appropriate where the ice in contact with the rock is at the pressure melting-point (which may be the case in parts of Antarctica), the value of m is 2 or 2 5 τ is given approximately[6] by $\rho g h \alpha$, where ρ is the mean density, h is the thickness, and α is the (small) slope of the upper surface averaged over a distance $\sim h$ Hence

$$u = \left(\frac{\rho g h \alpha}{A}\right)^m \tag{2}$$

u at a point is thus determined by the slope of the upper surface and the thickness at that point On the other hand, in a steady state, where the accumulation of snow on the upper surface is just balanced by the outward flow, u is also determined by the rate of accumulation of snow, integrated between the place under consideration and the 'centre' of the ice sheet This makes it possible, in principle, to calculate the steady-state profile of the upper surface, and with certain simplifying assumptions, such as uniform roughness of the bed, some analytical solutions can be derived[4]

Our present concern, however, is with departures from the steady state, and here the appropriate analysis has already been performed by Weertman[7] He uses equation (2) and considers an ice sheet moving down a uniform plane bed of slope β in the direction Ox , the assumption of uniform slope is not in fact necessary, and we may put β a function of x without altering the result (The effect of non-uniform roughness is treated in ref 4) In the steady state, the thickness is $h_0(x)$, the velocity is $u_0(x)$, and the thickness of ice added at the upper surface per unit time is $a(x)$ We put $dh_0/dx = -\varphi_0$ (φ_0 is positive) and $\alpha_0 = \varphi_0 + \beta$, so that α_0 is the steady-state slope of the upper surface Let there now be a departure $h_1\ (x, t)$ from the steady-state thickness, where $h_1 \ll h_0$, $\partial h_1/\partial x \ll \varphi_0$, $\partial h_1/\partial x \ll \alpha_0$, $\partial^2 h_1/\partial x^2 \ll d\alpha_0/dx$ Weertman then shows, solely from equation (2) and an equation of continuity, that the subsequent history of this perturbation is given by

$$\frac{\partial h_1}{\partial t} = -Bh_1 - C\frac{\partial h_1}{\partial x} + D\frac{\partial^2 h_1}{\partial x^2} \tag{3}$$

B, C and D being fixed by the steady-state parameters as follows

$$\left.\begin{aligned} B &= (m+1)(\varphi_0 u_0 + a)/h_0 \\ C &= \{(m+1)(\alpha_0 + \varphi_0)u_0 - (m-1)a\}/\alpha_0 \\ D &= m u_0 h_0/\alpha_0 \end{aligned}\right\}$$

The three terms on the right in equation (3) have simple meanings[7] The term $-Bh_1$ represents an exponential decay with a time constant B^{-1} Putting $m = 2\ 5$, $h_0 = 3{,}000$ m , $u_0 = 20$ m /yr , $\varphi_0 = 3 \times 10^{-3}$, $a = 0\ 1$ m /yr gives $B^{-1} = 5{,}000$ yr This term is concerned with departures from the equilibrium thickness, rather than from the equilibrium slope It shows that such departures, extending, as we shall see, over long distances comparable with the size of the whole ice sheet, can persist for several thousand years—long, that is, compared with the period for which the rate of accumulation can be considered steady The term $-C\partial h_1/\partial x$ represents a travelling wave of constant h_1 moving with a velocity C This wave is akin to the kinematic waves of Lighthill and Whitham[8] Putting $\alpha_0 = \varphi_0$ and the other values as before gives $C = 90$ m /yr (We may note in passing that, for small u_0, C can be negative that is, the wave can travel upstream This happens up to distances of about 200 km from the centre) The term $D\partial^2 h_1/\partial x^2$, which is the one of primary interest in the present application, represents an outward spreading and broadening of an initial disturbance in accordance with the diffusion equation The characteristic time for the 'diffusion' process will depend on the length of the waves If there are surface waves of wave-length λ, the characteristic time will be[4] $\left(B + \frac{4\pi^2 D}{\lambda^2}\right)^{-1}$ Putting in numerical values as before and taking $\lambda = 12$ km (the mean observed wave-length), we find the time to be 0 07 yr (B is negligible here) Thus surface waves as short as 12 km will disappear in a matter of months In order to survive for one year, a wave would need to have $\lambda > 40$ km , and for 10 years, $\lambda > 140$ km A wave with $\lambda/2$ equal to the width of the ice sheet 4,000 km) would last for 5,000 years At the other extreme we must recognize that the approximations of the theory break down when the wave-length becomes smaller than the thickness of the ice sheet, ay, 3 km , and waves with $\lambda \ll 3$ km —sastrugi, or example—will not be eliminated by the above mechanism Thus we conclude that departures from he equilibrium form of the ice sheet cannot survive or longer than one year if their wave-lengths are between about 3 (or less) and 40 km

The physical reason for this result may be explained s follows The upstream side of a crest will have a maller slope than normal, and the downstream side will have a greater slope This causes a greater shear tress on the bed, and therefore a greater velocity, on he downstream side The crest is therefore stretched nd flattened If, however, the crest is narrow compared with the depth of the ice sheet, as in sastrugi, he changes of slope do not affect the shear stress on he bed, and so the crest survives At the other xtreme, if the crest is very extensive, the additional urvature of the surface is so slight that a long time is eeded to eliminate it Between these two extremes here is a range of wave-lengths where the crests sappear in times less than one year

It follows from this analysis that, if comparatively ng-lived undulations are observed in the range of ave-lengths where waves are quickly eliminated, ey cannot be departures from the equilibrium ofile but are the result of the topography of the d This conclusion, from purely mechanical reasoning, will apply to the surface waves with $\lambda \sim 12$ km en in Antarctica, provided the waves cannot build by preferential accumulation in very short times cording to the above figures they could only be e to preferential accumulation if they were built within a few months—and this seems exceedingly likely in view of the measurements of annual cumulation interpreted from cores drilled on the ves by the Trans-Antarctic Expedition during e crossing[1,2] Incidentally, if our conclusion that e waves are the result of bed topography is rrect, one might expect to find the accumulation ther greater in the sheltered hollows than on the posed crests, and this does appear to be the case[1]

We must now ask how the topography of the bed ll influence the surface If m were infinite, equation (1) shows that the velocity of sliding would be zero up to a critical shear stress A, and, when $\tau = A$, u could take any value Putting m infinite in fact leads to the older theory[6] in which τ was regarded as constant everywhere on the bed of an ice sheet In this approximation, therefore, h is proportional to $1/\alpha$ Using this approximation, Bourgoin[3] has succeeded in making a detailed correlation between the very slight relief of the surface of the Greenland ice sheet and the relief of the bed measured by seismic sounding He found that an unevenness of the surface of as little as 10 m between two points 30 km apart denoted the presence of a hill in the bed rock about 350 m high This theory can now be improved by using the more general relation (1), in which m is finite and which allows for changes in τ It is then found[4] that a hill on the bed of height p, where $p \ll h$, produces (a) a change in height of the surface which is an order of magnitude less than p, (b) a change $\Delta\alpha$ in surface slope where

$$\frac{\Delta\alpha}{\alpha} = \frac{m+1}{m}\,\frac{p}{h} \simeq 1\ 4\,\frac{p}{h} \qquad (4)$$

and (c) a change $\Delta\tau$ of shear stress on the bed, where

$$\frac{\Delta\tau}{\tau} = \frac{1}{m}\,\frac{p}{h} \simeq 0\ 4\,\frac{p}{h} \qquad (5)$$

Thus a mountain 300 m high covered by ice 3,000 m thick shows itself as a change in height of the surface small compared with 300 m (as verified by Bourgoin's work), a change in surface slope of 14 per cent, and a change of shear stress on the bed of 4 per cent The smallness of this last figure is the reason for the success of the older theory in which τ was regarded as constant

In order to deduce the height of a buried mountain from the change of slope of the surface that it produces, we write (4) as

$$p = \frac{m}{m+1}\,\frac{h\Delta\alpha}{\alpha} \simeq 0\ 7\,\frac{h\Delta\alpha}{\alpha} \qquad (6)$$

The value of p deduced by putting m infinite is $h\,\Delta\alpha/\alpha$ Thus with the new theory, which allows τ to vary, we deduce values of p which are 70 per cent of those deduced on the older theory Generally speaking the accuracy of the seismic methods used in Greenland (and Antarctica) is not yet sufficient to check this change in the theoretical prediction

The fluctuations of surface slope observed in Antarctica are comparable with the average slope itself, and it follows from (4) that the heights of the submerged mountains are a large fraction of the total thickness of the ice sheet We are thus left with the conclusion that the surface waves in Antarctica, small as they are, reflect a very considerable relief of the rock bed—a relief which is already becoming apparent from the seismic and gravity work Greenland is very different , there the bed is comparatively uniform in the regions so far studied, and this shows itself in the extreme uniformity of the surface

[1] Geophysical Discussion of the Royal Astronomical Society, February 28, 1959, *Geophys J* (in the press) See also *Nature*, **183**, 1575 (1959)

[2] Lister, H (private communication)

[3] Bourgoin, J P , *Annales de Géophys* , 12, 75 (1956)

[4] Nye, J F , *J Glaciol* , 3 (Oct) (1959)

[5] Weertman, J , *J Glaciol* , 3, 33 (1957)

[6] Nye, J F , *Nature*, **169**, 529 (1952)

[7] Weertman, J , Union Géodésique et Géophysique Internationale, Association Internationale d'Hydrologie Scientifique, Symposium de Chamonix, September 16–24, 162 (1958)

[8] Lighthill, M J , and Whitham, G B , *Proc Roy Soc* , A, **229**, 281 (1955) Nye, J F , *Nature*, **181**, 1450 (1958)

NUCLEOTIDE-PEPTIDE COMPOUNDS OF *SACCHAROMYCES CEREVISIAE*

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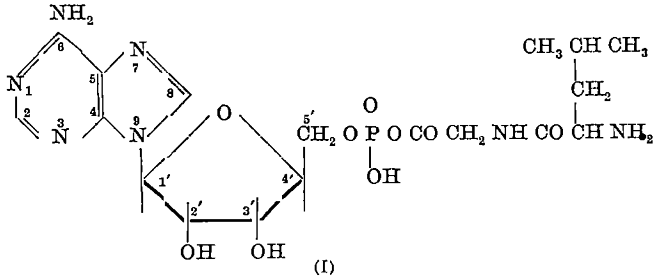
Synthetic 'Active' Nucleotide-Peptide Compounds

THE recent demonstration[1] of the presence in strains of *Saccharomyces cerevisiae* of nucleotide-peptide compounds containing an active carboxyl group in the peptide moiety and the isolation of individual compounds of this nature[2], which may function as protein precursors, made it clearly desirable to prepare model 'active' compounds

Methods already available[3-6] for the synthesis of the related amino-acid adenylates have therefore been applied to the elaboration of certain nucleotide-peptide compounds For example, application of the method of Berg[3], as modified by Kingdon *et al* [4] to the condensation by means of di*cyclo*hexyl carbodiimide in aqueous pyridine of adenylic acid with leucylglycine, has yielded a mixed nucleotide-peptide anhydride, although only in small yield The crude product was obtained from the reaction mixture by precipitating it by means of acetone, extracting the dried precipitate with weak acetate buffer at *p*H 4 0 and removing contaminating adenylic acid and polymers by adsorption of these impurities on 'Dowex-1' (formate) It was further purified by chromatography on Whatman 3 *MM* paper in the solvent system, *n*-propanol-ethyl acetate-water (7 1 2, v/v), elution with cold water and evaporation of the resulting solution in the cold

The product had an R_F value of 0 20 in the above chromatographic solvent and was therefore well differentiated from unchanged leucylglycine having an R_F value of 0 32 It gave a characteristic red coloration with ninhydrin reagent on paper and a strong red-brown coloration due to the formation of a ferric hydroxamate on treatment with hydroxylamine followed by ferric chloride under the conditions recommended by Koningsberger *et al* [1] These colour reactions and the behaviour of the compound on 'Dowex-1' (formate) resemble closely those given by the corresponding products from yeast With the latter, the synthetic compound shares also the further characteristic properties of migrating towards the cathode on electrophoresis on paper in acetate buffer at *p*H 4 0 and of having an ultra-violet absorption spectrum of the type given by the corresponding nucleoside From a consideration of its properties, the mode of synthesis and the fact that the compound yielded on hydrolysis equimolar proportions of adenine, ribose, phosphoric acid, leucine and glycine it may be deduced that the nucleotide-peptide has the structure (I) This resembles closely certain of the yeast constituents which, however, contain uracil in place of adenine, and it is of interest to record that replacement in the above synthesis of adenylic acid by uridylic acid results in the formation of a product of very similar properties with the exception that it is less readily desorbed from 'Dowex-1' (formate) Again, the substitution of the tripeptide DL-leucyglycylglycine for the above dipeptide yields analogous products, and present efforts are therefore being made to extend the synthesis to certain of the naturally occurring nucleotide-peptide compounds

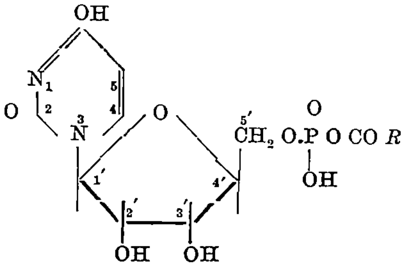


(I)

A Second Nucleotide-Peptide Compound from Brewers' Yeast: Isolation and Structural Observations

THE initial discovery[2] of a nucleotide-peptide compound in cold ethanol extracts of a brewer's yeas and the possibility that such compounds might play a part in protein synthesis prompted a search fo other substances of this nature It has now been observed that extraction of *Saccharomyces cerevisia* (No 240 of the British National Collection of Yeas Cultures) by means of hot aqueous ethanol, following inactivation of the cells with cold ethanol and ether yields a mixture containing several nucleotide-peptide compounds Treatment of the extract with 'Dowex-1' (chloride) resulted in adsorption of certain of these compounds among others on the resin, whil desorption of some of the adsorbed material wa achieved by treatment of the resin with acetat buffer solution at *p*H 5 0 The concentrate thu obtained was freed from various nucleotides, peptide and amino-acids by successive adsorption of thes compounds on 'Dowex-1' (formate) and 'Amberlit *CG* 50' (acid form) and was then subjected to electrophoresis in acetate buffer at *p*H 4 0 on Whatman No 3 paper Elution by means of cold water of tha material on the final electropherogram which had th properties of (*a*) migrating towards the cathode (*b*) reacting with hydroxylamine to form a hydroxami acid[1,2], and (*c*) yielding a coloration with ninhydrin gave a preparation, which on freeze-drying an freeing from salt by solution in wet ethanol, followe by precipitation with ether, yielded a homogeneous nucleotide-peptide

The product migrated as a single narrow band on electrophoresis as above an formed one well-defined chromatographi zone in the solvent systems compose (*a*) of butanol, acetic acid and water (4 1 v/v), and (*b*) of ethyl acetate, propan and water (1 7 2, v/v) As indicate above, it formed a hydroxamic acid o reacting with hydroxylamine under th conditions described by Koningsberger il[1] and it gave a red coloration on heating with ninhydrin In acid solution, its absorption spectrum displayed maxima at 235 and 265 mμ, the peaks corresponding presumably to the absorption due to the peptide and nucleotide moieties, respectively The molecule was broken down into its constituent parts by treatment with cold alkalis, for example odium hydroxide, aqueous ammonia or hydroxylamine, the nucleotide portion displaying the chromatographic[7], electrophoretic and light absorption properties characteristic of uridine-5′-phosphate The peptide-hydroxamic acid formed by treatment of the original nucleotide peptide with hydroxylamine behaved chromatographically as a single ubstance which on hydrolysis with acid yielded only arginine and α-alanine as judged by chromatoraphy and colour reactions[8] The treatment with lkalis naturally resulted in the loss of reactivity owards hydroxylamine



(II)

here R represents a tetrapeptide residue consisting f two arginine and two α-alanine units

The presence of a uridylic acid residue in the ucleotide–peptide compound was confirmed by ydrolysing the latter material (*a*) with formic acid o produce uracil, itself estimated by ion-exchange romatography[9], (*b*) phosphate[10] (1 mole), and) ribose (1 mole)[11,12] The composition of the peptide was ascertained by hydrolysis with hydrochloric acid followed by chromatography on paper The arginine and α-alanine were eluted by means of dilute acid and estimated by the colorimetric method of Yemm and Cocking[13], whereupon it was found that the molecule contained two residues each of the above amino-acids The evidence indicates that the nucleotide–peptide now described is a mixed anhydride (II) of uridine-5′-phosphate with a tetrapeptide containing two units of α-alanine and two units of arginine The site of the 'active' anhydride grouping at the 5′-position of the uridine-5′-phosphate is indicated (*a*) by the loss of reactivity towards hydroxylamine coincident with fission of the molecule by means of alkalis, (*b*) the formation of a peptide-hydroxamic acid, and (*c*) by the fact that the compound itself is immediately attacked by periodate, thus demonstrating the lack of substituents on the 2′ and 3′ positions The close structural relationship between the nucleotide–peptide here described and the mixed 5′-phosphoanhydrides of adenosine-5′-phosphate with various single amino-acids, taken together with the fact that the latter anhydrides are held to be implicated in protein synthesis, suggests that the peptide derivatives also might play a part in cell growth

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[1] Koningsberger, V V , van der Grinten, C O , and Overbeek, J T G , *Biochim Biophys Acta*, **26**, 483 (1957)

[2] Harris, G , Davies, J W , and Parsons, R , *Nature*, **182**, 1565 (1958)

[3] Berg, P , *Fed Proc* , **16**, 151 (1957) , *J Biol Chem* , **233**, 608 (1958)

[4] Kingdon, H S , Webster, L T , and Davie, E W , *Proc U S Nat Acad Sci* , **44**, 757 (1958)

[5] McCorquodale, D J , and Mueller, G C , *Arch Biochem Biophys* , **77**, 13 (1958)

[6] Lambert, R , Zilliken, F , and Gurin, S , *Angew Chem* , **70**, 571 (1958)

[7] Kirby, K S , *Biochim Biophys Acta*, **18**, 575 (1955)

[8] Jepson, J B , and Smith, I , *Nature*, **172**, 1100 (1953)

[9] Cohn, W E , *Science*, **109**, 377 (1949)

[10] Umbreit, W W , Burris, R H , and Stauffer, J F , "Manometric Techniques and Tissue Metabolism", 190 (Burgess, Minneapolis, 1951)

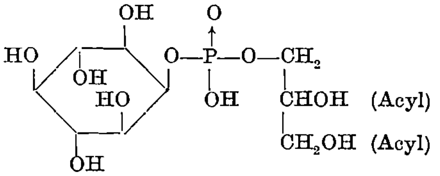
[11] Mejbaum, W , *Z physiol Chem* , **258**, 117 (1939)

[12] Fiske, C H , and Subbarow, Y , *J Biol Chem* , **66**, 375 (1925)

[13] Yemm, E W , and Cocking, E C , *Analyst*, **80**, 209 (1955)

SYNTHESIS AND PROPERTIES OF 1-GLYCERYL-2-*MYO*-INOSITYL PHOSPHATE

THE simplest member of the glycerinositol phosphatides[1] is considered to be a diacyl derivative of 1-glyceryl-2-*myo*-inosityl phosphate)[2–4], since on hydrolysis it yields glycerol, *myo*-ositol, glyceryl phosphate, *myo*-inosityl phosphate nd fatty acids, the ratio fatty acids, glycerol, ositol, phosphorus being 2 1 1 1



(I)

Although there is strong evidence for formula (I), ubt still exists concerning the position of the hosphate group because of its tendency to migrate adjacent hydroxyl sites under the conditions hydrolysis[5,6] We have therefore synthesized 1-glyceryl-2-*myo*-inosityl phosphate for comparison with the natural product This was kindly undertaken by Dr J N Hawthorne, who found our synthetic product identical with his own specimen, isolated from ox liver and with a specimen synthesized by a different route (see second communication)

T MALKIN

Synthesis of 1-Glyceryl-2-*myo*-inosityl Phosphate

3 4 5 6-TETRACETYL-*myo*-INOSITOL[7] in pyridine, when treated with 1 25 moles of acetyl chloride in benzene, yielded 1 3 4 5 6-pentacetyl-*myo*-inositol in 78 per cent yield, shown by mixed m p 172–74° C , and mixed m p of *p*-nitrobenzoyl esters 232–35° C , to be identical with the pentacetate obtained by the stereospecific reduction of pentacetyl-*scyllo*-inosose[8–10] This pentacetate, when treated with phenylphosphorodichloride, 1 1 moles, in lutidine at 40° C for 48 hr , followed by addition of 1 2-*iso*propylidene-

glycerol, 5 moles, at 50° C , and stirring for 36 hr , gave 1 2-*iso*propylidene-glyceryl-pentacetyl-2-*myo*-inosityl-phenylphosphate, as colourless crystals from ethanol, m p 140–42° C , in 52 per cent yield (found C, 51 0 , H, 5 7 , P, 4 7 $C_{28}H_{37}O_{16}P$ requires C, 50 9 , H, 5 6 , P, 4 7 per cent Hydrogenolysis in ethanol or ethyl acetate, in the presence of Adams's catalyst, removed the phenyl group, and the resultant acidity was sufficient to cause the loss of the *iso*propylidene group, on dissolution in water and standing overnight Evaporation of the solvent at < 40° C gave the glyceryl-pentacetyl-inosityl-phosphate as a deliquescent glass, which was characterized as the *cyclo*hexylamine salt, m p 204° C (found C, 46 2 , H, 6 7 , N, 2 2 , P, 4 7 per cent , $C_{25}H_{42}O_{18}P\,N$ requires C, 46 6 , H, 6 5 , N, 2 2 , P, 4 8 per cent Sodium methylate in methanol converted the pentacetyl compound into sodium glyceryl-*myo*-inosityl-phosphate, which was separated in a centrifuge and converted into the free acid by passing an aqueous solution down a column of '*IR* 120' resin Evaporation to dryness at < 40° C gave a deliquescent glass, which was quite unsuitable for characterization or for handling Sodium, potassium and barium salts were made by passing an aqueous solution of the phosphate down a column of '*IR* 120' resin in the appropriate basic form Both the former are very deliquescent, but the latter is less so and can be handled reasonably well The removal of protecting groups is carried out with an overall yield of 70–75 per cent

Since most of the natural glyceryl phosphatides occur in the L-form, we have carried out the same synthesis, using D-*iso*propylidene glycerol[11], which yields the L-glyceryl phosphate , but although various optically active intermediates were obtained, the final glyceryl-inosityl-phosphate was inactive Racemization is, of course, to be expected, once the protecting *iso*propylidene group is removed, because of the phosphate equilibrium between the 1 2-positions of the glycerol, and this appears to be particularly rapid, when all the protecting groups are removed It is, however perhaps too early to discuss this aspect of the work in detail, as so little is yet known about the activity of the natural compounds

L-*iso*propylidene-glyceryl-1 3 4 5 6-pentacetyl-*myo*-inosityl-phenyl-phosphate was made as described for the DL-compound The m p and mixed m p with the DL-compound are surprisingly the same (140–42° C) , $[\alpha]_D^{21}$° + 2 34° C in chloroform, $[\alpha]_D^{21}$° + 2 4 in ethyl acetate

Hydrogenolysis of the above and neutralization with $N/10$ sodium hydroxide (phenolphthalein) gave sodium L-*iso*propylidene-glyceryl-1 3 4 5 6-pentacetyl-*myo*-inosityl-phosphate , $[\alpha]_D^{21}$° + 3 25° C , in chloroform (found C, 43 3 , H, 5 2 , P, 5 0 $C_{22}H_{32}O_{16}P\,Na$ requires C, 43 5 , H, 5 2 , P, 5 0 per cent) This, on deacetylation, gave sodium L-*iso*propylidene-glyceryl-*myo*-inosityl-phosphate as a deliquescent white powder , $[\alpha]_D^{21}$° − 1 04° C in water

For comparison with the natural products, we sent the barium salt of glyceryl-*myo*-inosityl phosphate, prepared from D-*iso*propylidene glycerol, to Dr J N Hawthorne Our own hydrolysis and paper chromatographic comparisons showed it to be identical with that obtained from inactive *iso*propylidene glycerol

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1-Glyceryl-2-*myo*-inositol Phosphate: Alternative Synthesis and Behaviour on Hydrolysis

BY a mild alkaline hydrolysis of liver phosphatidy inositol (Formula I, previous communication) th two fatty acids have been selectively removed, an glyceryl-*myo*-inosityl phosphate prepared Afte purification on an ion-exchange column, it has bee broken down to a mixture of glycerophosphate an inositol monophosphate by hydrolysis with 0 5 *N* sodium hydroxide at 100° C for 40 min[12] Fc comparison with glyceryl-*myo*-inosityl phosphat prepared in this way, a synthetic sample was require 1-Glyceryl-2-*myo*-inosityl phosphate was chosen fc this work

The method of phosphorylation used in the preser synthesis is that which has been developed by Gilhai and Khorana[13] a phosphate monoester and a alcohol, under the influence of di*cyclo*hexylcarbod imide in anhydrous pyridine, condense together give a phosphate diester (This work began befo the method of Gilham and Khorana appeared W are grateful to Dr Khorana for sending details advance of publication) This method has n previously been applied to the syntheses of phosph lipids or their intermediates

The alcohol used in the present work was DL-*is* propylidene glycerol[14] and the phosphate monoest was 1 3 4 5 6-penta-acetyl-*myo*-inositol-2-pho phate This latter compound was prepared by modification of Iselin's five-stage synthesis[8] *my* inositol was oxidized by *Acetobacter suboxydans* scyllo-inosose This was acetylated to its penta acetate with acetic anhydride containing 0 3 per cer perchloric acid The catalytic reduction of th compound is difficult[10], presumably because th carbonyl group is sterically hindered and it wa eventually found necessary to carry out the hydr genation in glacial acetic acid The reaction is n completely stereospecific in this solvent and a mixtu of *myo*-inositol and scyllitol penta-acetates is forme The mixture was phosphorylated with diphen phosphorochloridate in pyridine at 80° C for 20 h The product, recrystallized from dry ethanol, ha m p 183–88° C The yield was 66 per cent Th phenyl groups were removed by hydrogenolysis dry ethanol with Adams's catalyst, and the contan inating scyllitol isomer was then removed by fraction crystallization from the concentrated ethanol solutic at room temperature , the penta-acetyl scyllit phosphate had m p 249–51° C , yield 5 per cen the penta-acetyl inositol phosphate had m p 23 32° C after recrystallizing from dry ethanol, yie 64 per cent

DL-*iso*propylidene glycerol (0 5 ml) and pent acetyl inositol-2-phosphoric acid (0 2 m mole) we allowed to react together in anhydrous pyridi (5 ml) with di*cyclo*hexylcarbodiimide (1 5 m mole for 2 days at room temperature Water was add and the precipitated di*cyclo*hexylurea removed centrifugation The *iso*propylidene group was moved by stirring with a large excess of 'Zeo-Karb 22 (H^+-form) overnight The solution was concentrat to a small volume *in vacuo* at a bath temperatu of less than 40° C and the acetyls removed as the hydroxamates hydroxylamine was prepared reaction of its hydrochloride with the calculat amount of sodium metal in dry methanol and add in excess to the phosphate solution It was allow to react for 20 min

The reaction mixture contained 25–30 per cent glyceryl-*myo*-inosityl phosphate, free inositol monophosphate, and a third component which is probably *bis* inositol pyrophosphate These compounds were separated by chromatography on 'Dowex-1' using borate–formate mixtures for elution[12] The synthetic glyceryl-*myo*-inosityl phosphate was eluted at the same formate concentration as the natural material Determination of glycerol by the chromotropic acid method[4b] showed a glycerol to phosphorus molar atio of 1 0(03)/1

The synthetic product was subjected to the same alkaline hydrolysis that has been used for the glyceryl-*myo*-inosityl phosphate isolated from the inositide The hydrolysate, complexed with borate in he usual manner, was analysed into its components n a 'Nalcite *SAR*' column[4b] No phosphate was ow eluted with the glyceryl-*myo*-inosityl phosphate luting agent, but two peaks appeared in the positions where inositol monophosphate and glycerophosphate re known to occur Only the second, corresponding o glycerophosphate, contained glycerol 31 per cent f the phosphorus was present in the inositol phoshate peak

For comparison, the barium salt of glyceryl-*myo*-nosityl phosphoric acid prepared in the Bristol aboratories was hydrolysed by the same method Analysis by the chromotropic acid method showed hat it contained the theoretical amount of glycerol The inositol monophosphate and glycerophosphate roduced by hydrolysis were separated on a column s above In two analyses 31 and 35 per cent of the hosphate in the hydrolysate was in the form of nositol monophosphate

This hydrolytic pattern agrees well with that obtained with glyceryl-*myo*-inosityl phosphate prepared from the liver phosphatidyl inositol[12] In addition, Hanahan and Olley[15] found that alkaline hydrolysis of the lipid itself gave 35 per cent phosphorus in the form of inositol phosphate It is likely, therefore, that the natural product has a similar configuration, involving inositol-2- or 1-phosphate A decision between these two should be possible since only the 1-compound is optically active[16]

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[1] For references see Folch, J , and LeBaron, F N , *Canad J Biochem Physiol* , **34**, 305 (1956)

[2] Morelec-Coulon, M J , and Faure, M , *C R Acad Sci* , *Paris*, **236**, 1104 (1953) , **238**, 411 (1954) *Bull Soc Chim Biol* , **40**, 1307 (1958)

[3] McKibbin, J M , *Fed Proc* , 13, 262 (1954) , *J Biol Chem* , **220**, 537 (1956)

[4] (*a*) Hawthorne, J N , *Biochem J* , 59, 2P (1955) (*b*) Hawthorne, J N , and Hubscher, G , *ibid* , **71**, 195 (1959)

[5] See Malkin, T , *Chem and Indust* , 1186 (1956)

[6] Posternak, T , *Helv Chim Acta*, 41, 1891 (1958) , **42**, 390 (1959)

[7] Angyal, S J , Gilham, P T , and Macdonald, C G , *J Chem Soc* , 1415 (1957)

[8] Iselin, B M , *J Amer Chem Soc* , **71**, 3822 (1949)

[9] Posternak, T , *Helv Chim Acta*, **24**, 1045 (1941)

[10] May, E L , *J Org Chem* , **17**, 286 (1952)

[11] Baer, E , *Biochem Prep* , **2**, 31 (1952)

[12] Hawthorne, J N , and Hubscher, G , *Biochem J* , **72**, 10,P (1959)

[13] Gilham, P T , and Khorana, H G , *J Amer Chem Soc* , **80**, 6212 (1958)

[14] Renoll, M , and Newman, M S , *Organic Syntheses*, **28**, 73 (1948)

[15] Hanahan, D J , and Olley, J N , *J Biol Chem* , **231**, 813 (1958)

[16] Pizer, F L , and Ballou, C E , *J Amer Chem Soc* , **81**, 915 (1959)

FUNCTIONAL ORGANIZATION OF THE RESPIRATORY CHAIN IN LIVER MITOCHONDRIA

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THE question of whether the mitochondrion is compartmentalized into separate respiratory ains serving the individual cytochrome-linked hydrogenases and acting independently of each her, or whether all or most of these dehydronases are structurally and functionally linked to common electron transport system, has been an en and much debated one In the past, two major proaches have been used to explore this question ne entails the isolation of mitochondrial fragments pable of oxidizing only one substrate at significant tes (such as a reduced diphosphopyridine nucleotide idase preparation[1]) and the other the measurement the extent of reduction of the various cytochrome mponents in anaerobiosis in intact mitochondria[2] sewhere[3], we have discussed the limitations of these thods and the consequent uncertainties of the nclusions derived from their application A series alternative methods have been employed by ngler and Singer[3,4] to a study of the respiratory ain in brain mitochondria and some of the same thods have been applied by Wu and Tsou[5] to ilin–Hartree preparations of pig heart in their study the interrelation of succinic and reduced diphosphoridine nucleotide oxidases

The following possibilities have been considered in the present study (1) There may be a separate and distinct cytochrome chain serving each cytochrome-reducing dehydrogenase in mitochondria, with no interconnexion between the chains (2) Two or more dehydrogenases may be attached to any given chain, but there is no functional interconnexion between the chains (3) Two or more dehydrogenases may be linked to a given cytochrome chain, and there is intercommunication (that is, electron transport) among all the chains in a given mitochondrion The third alternative recognizes the least degree of specialization for the electron transport system Both alternatives (2) and (3) pose the further question as to the point in the chain at which a bifurcation to the various dehydrogenases might occur In the present investigation these alternatives were examined in sucrose mitochondria of rat liver, using the succinic and choline oxidase systems as indicators, since both specific dehydrogenases have been isolated and sufficiently characterized to permit the conclusion that they are flavoproteins The techniques employed in order to decide among the aforementioned possibilities included (*a*) a study of the rate of the cross-reaction in anaerobiosis between the two dehydrogenases and of the effect of inhibitors thereon ;

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Table 1 COMPETITION OF SUCCINIC AND CHOLINE DEHYDROGENASES FOR THE RESPIRATORY CHAIN

Experiment	Electron acceptor	Substrate	Oxygen uptake (μ atoms)	Fumarate formed (μ moles)
1	Respiratory chain, cyt a_3 limiting (3 3 m*M* azide)	Succinate Choline Succinate + choline	40 0 20 0 35 6	36 0 28 0
2	Phenazine methosulphate	Succinate* Choline Succinate* + choline	51 2 55 4 112	
3	Respiratory chain, cyt $b \rightarrow c_1$ limiting (9 3 × 10^{-7} *M* quinoline oxide)	Succinate Choline Succinate – choline	22 2 12 5 36 1	22 8 24 6

* Succinic dehydrogenase activity depressed by titration with malonate to the level of choline dehydrogenase

Conditions Manometric assays at 30°, *p*H 7 6, in the presence of 0 02 *M* succinate and/or 0 017 *M* choline and sucrose mitochondria of rat liver The reaction period and the amount of mitochondria were varied in the different experiments, but the results are expressed for a 15-min period and 1 ml mitochondrial suspension The latter contained 25 2 mgm protein in experiments 1 and 2, and 25 9 mgm in experiment 3 In experiments 1 and 3, 0 5 mgm cyt *c* was added Fumarate was determined, after deproteinization, with crystalline fumarase and the malic enzyme of *L arabinosus* (ref 9)

(*b*) comparison of the quantitative effect of the titration of mitochondria with respiratory chain inhibitors on the two enzyme systems , (*c*) a study of the effect of depletion and re-addition of a specific component of the respiratory chain on the two activities , (*d*) competition experiments between the two enzyme systems for specific components of the respiratory chain

The investigations of Slater[6] and of Wu and Tsou[5] of the reduced diphosphopyridine nucleotide and succinic oxidases of heart and of Ringler and Singer[3 4] of the succinic and α-glycerophosphoric oxidases of brain have ruled out the possibility that separate and specific cytochrome chains serve these dehydrogenases in the tissues mentioned, but did not permit distinguishing between alternatives (2) and (3) In contrast, the results of a comparison of the behaviour of choline and succinic oxidases in rat liver did not seem to be readily reconcilable with the operation of a common respiratory chain and suggested that at least a part of their cytochrome chains may operate independently of each other Thus, anaerobically, no oxidation of choline by fumarate could be detected, the oxidation of choline and succinate via the complete chain was additive, not competitive , addition of cytochrome *c* to partially depleted mitochondria stimulated succinate oxidation three- to four-fold but did not affect choline oxidation, and titration with azide, cyanide, antimycin *a*, and 2-*n*-heptyl-4-hydroxyquinoline N-oxide (quinoline oxide) inhibited succinate oxidation at much lower concentrations than choline oxidation (Fig 1) Further, amytal completely inhibited choline respiration without inhibiting succinate oxidation

Since during the steady state both choline and succinate reduce all the known cytochromes of liver mitochondria (b, $c + c_1$, a, a_3), although to different extents[8], and since the differential effects of amytal were readily explained, without postulating separate pathways, by the finding that this inhibitor acts between choline dehydrogenase flavoprotein and cytochrome *b*[8], it was desirable to establish whether the differential effects on choline and succinic oxidases might not be the results of the greater activity of succinic than of choline dehydrogenase and of the consequently greater demand it puts on the respiratory chain In order to test this possibility, succinic dehydrogenase activity was depressed by malonate to a point where it equalled choline dehydrogenase activity Under these conditions, external cytochrome *c* no longer stimulated either succinic or choline oxidase, since the residual cytochrome *c* in washed sucrose mitochondria was sufficient to support this lowered rate of respiration Similarly, when succinic and choline dehydrogenase activities were equalized by malonate titration, the titration curves of choline and succinic oxidases (and of the corresponding cytochrome *c* reductases) with all the respiratory chain inhibitors mentioned coincided

Since the activity of choline oxidase in rat liver mitochondria is only 20–25 per cent as high as that of succinic oxidase, it seemed possible that the turnover-rate of the slowest member of the cytochrome chain in liver mitochondria (supplemented with cytochrome c) may exceed the combined activity of the two oxidases and that, therefore, in order to demonstrate a competition between the two oxidases it is necessary to depress the turnover of one of the components of the respiratory chain Indeed, when the turnover of cytochrome a_3 was depressed by titration with azide, the mutual competition of choline and succinic oxidases could be readily demonstrated (Table 1, exp 1) Significantly, as in the mutual competition of succinic and α-glycerophosphoric dehydrogenases in brain mitochondria, when the two substrates are simultaneously oxidized, the rate is *less* than that of the faster of the two oxidations The reasons for this have been discussed elsewhere[4] That the depression of succinate oxidation is the direct result of the operation of choline dehydrogenase is shown by the fact that the addition of 3 m*M* amytal, under these conditions, completely inhibits choline oxidation and re-establishes the rate of succinate oxidation and fumarate formation to the level found with succinate alone present When the respiratory chain is by-passed by intercepting electrons with phenazine methosulphate (exp 2) the competition disappears and a strict additiveness is obtained It may be concluded that the electrons originating from these two dehydrogenases flow through a common transport system, at least at the level of cytochrome oxidase

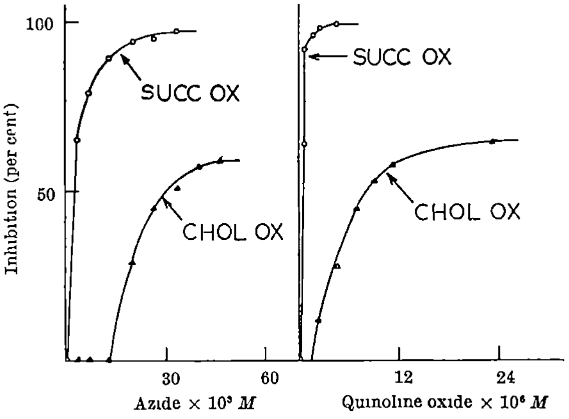

Fig 1 Titration of succinic oxidase and choline oxidase activities of sucrose mitochondria of rat liver with respiratory chain inhibitors Manometric assay of uptake of oxygen at 30° as in Table 1 The inhibitions were calculated from the linear rate of respiration in the interval 5–20 min after addition of the substrate The initial rate of respiration (0–5 min), before the inhibitor-resistant oxidation of choline is manifest (cf below), gives similar differences in the titration of the two oxidases, but the inhibition of both enzymes reaches completion

When antimycin or quinoline oxide was used to limit the rate of the cytochrome $b \rightarrow c_1$ step, instead of competition, additive rates were obtained (exp 3) This is interpreted to mean that the cytochrome b moieties serving succinic and choline dehydrogenases are not the same nor in direct intercommunication. Further support for this conclusion came from a detailed study of the azide-, CN^--, antimycin- and quinoline oxide-resistant oxidation of choline (Fig 1) Using an oxygen electrode, it was demonstrated that immediately following the addition of choline to mitochondria, treated with any of these inhibitors in excess, the oxidation is completely inhibited, but after 3–5 min at 30° C or after 10–20 min at room temperature, a respiration resistant to all these inhibitors begins The cytochrome *b* linked to choline dehydrogenase (but not that linked to succinic dehydrogenase) appears to be the site of the 'leak' and the resistance to inhibitors is thought to represent a conversion of this cytochrome *b* to an auto-oxidizable form for the following reasons (1) Choline dehydrogenase is not auto-oxidizable (2) Amytal inhibition of choline oxidation is complete but antimycin or quinoline oxide inhibition is not Thus, the 'leak' is between flavoprotein and cytochrome c_1 (3) Choline-cytochrome *c* reductase is completely blocked by all three of these inhibitors (4) The auto-oxidizable component through which succinate and choline oxidations occur with excess azide or CN^- present is he same, since under these conditions the rate of espiration per mgm mitochondria is equal whether uccinate, choline, or both are present Thus, the two ehydrogenases compete for the leak (5) That the *b* omponent linked to choline dehydrogenase (and not hat serving succinic dehydrogenase) is the site of the eak is indicated by the fact that while choline xidation is partially resistant to antimycin and uinolineoxide (agents which inhibit the $b \rightarrow c_1$ tep), succinic oxidase is completely inhibited by hese compounds

The auto-oxidation or reduced cytochrome *b* in ertain types of heart muscle preparations in the resence of cyanide was first observed by Keilin[10] ecently, Chance[11] questioned the evidence for the rect reaction of cytochrome *b* with oxygen at a gnificant rate In view of the slow rate of he development of the cyanide- and azide-resistant spiration in liver mitochondria, the auto-oxi- ation of cytochrome *b* possibly may escape tection in spectrophotometric experiments of very short duration, as employed by the Philadelphia group[11,12]

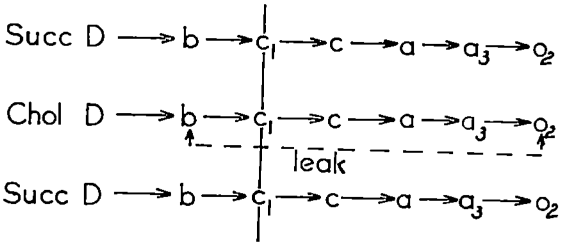

Fig 2 Schematic representation of the interrelations of succinic and choline oxidases in rat liver mitochondria

The findings suggest that the respiratory chains of liver mitochondria, at least so far as the succinic and choline oxidase systems are concerned, are not compartmentalized, but are interlinked at and above the oxidation-level of cytochrome c_1, although the *b* components do not appear to be on a common path (Fig 2) Intercommunication between the chains (alternative (3) above) is indicated by the fact that the quantitative effect of titration with an inhibitor, such as azide or cyanide, depends on the relative turnover rates of the dehydrogenase and the cytochrome component being titrated, respectively, and may be altered by depressing the activity of the dehydrogenase Neither mechanism (1) nor (2) is compatible with this behaviour, but it is to be expected from the third one

This work was supported by grants from the National Heart Institute, United States Public Health Service, and the American Heart Association, and by a contract (*Nonr* 1656(00)) between the Office of Naval Research and the Edsel B Ford Institute for Medical Research

[1] Green, D E, "Harvey Lectures, 1956–57", 177 (Academic Press, New York, 1958)
[2] Chance, B, Proc Int Symp Enzyme Chem, Tokyo and Kyoto, 1957, 9 (Maruzen, Tokyo, 1958)
[3] Ringler, R L, and Singer, T P, *J Biol Chem* (in the press)
[4] Ringler, R L, and Singer, T P, *Arch Biochem and Biophys*, **77**, 229 (1958)
[5] Wu, C Y, and Tsou, C L, *Scientia Sinica*, **4**, 137 (1955)
[6] Slater, E C, *Nature*, **165**, 674 (1950)
[7] Rendina, G, and Singer, T P, *Fed Proc*, **18**, 308 (1959)
[8] Estabrook, R L, Packer, L, Singer, T P, and Kimura, T (unpublished work)
[9] Korkes, S, in "Methods in Enzymology", edit by Colowick, S P, and Kaplan, N, **3**, 435 (Academic Press, Inc, New York, 1955)
[10] Keilin, D, *Proc Roy Soc*, B, **104**, 206 (1928)
[11] Chance, B, *J Biol Chem*, **233**, 1223 (1958)
[12] Chance, B, and Williams, G R, *J Biol Chem*, **217**, 395 (1955)

IS THE MULTIMAMMATE RAT A NATURAL RESERVOIR OF *BORRELIA DUTTONI*?

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OR about two years now, the Entomological Department of the South African Institute for edical Research, Johannesburg, has been carrying t transmission experiments and epidemiological vestigations on relapsing fever (*Borrelia duttoni*) in chuanaland, in collaboration with the Medical partment of that Protectorate

With the help of Dr E L Szlamp, medical officer Maun, a strain of *Borrelia duttoni* was isolated m tampans (*Ornithodoros moubata*) collected in a t in Maun, inhabited by a native suffering from an acute attack of relapsing fever Eleven specimens of *O moubata* were collected on December 5, 1958, and were injected into six white mice on December 17 All the mice became positive between December 23 and 29, 1958

This 'Maun' strain was then used for a great number of transmission experiments, on which a report will be given in a later paper Up to now, quite a few interesting results have been obtained, but one is of special interest and is reported in this preliminary note In our search for the natural reservoirs of African relapsing fever, which I expect to find among wild rodents, we also injected several specimens of the indigenous multimammate rat (*Rattus natalensis* = *Mastomys coucha*) with the 'Maun' strain and found that this wild rat is very highly susceptible to *Borrelia duttoni* although, judging from the general appearance and behaviour of the animals, there are no obvious clinical symptoms The same is true for the white mouse, but in the multimammate rat the parasitæmia of the blood is much higher, and persists, almost without interruption, for a longer period A photomicrograph of a blood smear of a white mouse at the peak of the blood-parasitæmia (ninth day after subcutaneous injection) is shown in Fig 1, and one of a blood-smear from a multimammate rat at a corresponding peak (eleventh day after injection) is given in Fig 2

The course of the infection in the above-mentioned white mouse was as follows It was infected on June 2, 1959, with an emulsion of eggs laid by an infected *O moubata* The first few spirochætes were detected in the blood-smear on June 10 The next day the smear was positive (Fig 1), and it did not reach this degree of parasitæmia again On June 13, only a few spirochætes were present in the field On the two following days the blood smears were negative On June 17 the result was recorded as + + A few spirochætes were again detected in the smear on June 20, 24 and 27 On the intervening days, and after June 27, all smears were found to be negative

The specimen of multimammate rat was injected on June 2 with a brain emulsion from a white mouse On June 9, the first spirochætes appeared in the blood and were recorded as ++ The next day no spirochætes could be detected in the smear They re-appeared on June 11 and increased steadily until June 15, when they reached the peak shown in Fig 2 The rat then remained highly positive until June 27 On the following two days the blood was negative , then another peak was reached on July 3 The rat was then still in the best condition of health, and its progress is to be followed up Similar results were obtained with other specimens of the multimammate rat

These results, which are to be consolidated by further experiments have suggested several interesting problems One is that the multimammate rat, used in this Institute for some time for many investigations on plague, cancer and bilharzia, is evidently a much better experimental animal for investigations on relapsing fever than the white mouse It may perhaps prove to be an ideal biological test-animal for silent infections in humans, where spirochætes are so rare in the blood that they cannot be detected by the usual laboratory methods

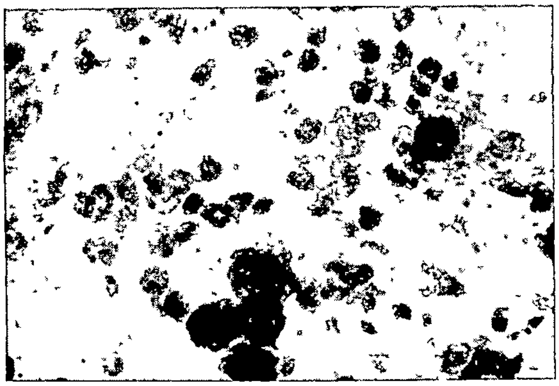

Fig 1 Blood smear of white mouse on the ninth day after subcutaneous infection with *Borrelia duttoni*

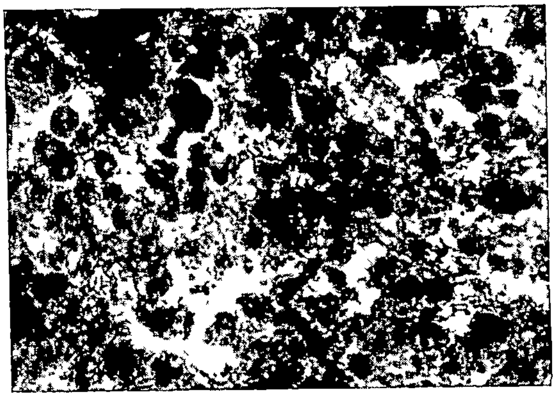

Fig 2 Blood smear of multimammate rat on the eleventh day after subcutaneous infection with *Borrelia duttoni*

Another problem is an epidemiological one It is now almost certain that the natives get their tampans from the burrows of wart-hogs All the wart-hog burrows which I have been able to check in the Bechuanaland Protectorate have been highly infested with tampans which, according to Dr G A Walton (by letter), are, with scarcely any doubt, morphologically and physiologically identical with those found in the huts in Maun and other places in the Bechuanaland Protectorate and the Northern Transvaal But the ticks collected by us from burrows in these areas, and also those collected by other authors in Central Africa, have never been found infected with *Borrelia* Further, the wart-hog itself has never been found infected and is refractory when infected experimentally (comp Geigy and Mooser[1]) Evidently the wart-hog is not a natura reservoir of African relapsing fever, and the ticks may acquire their infection from another animal Incidentally, the 'wild' *Ornithodoros moubata* from the burrows of wart-hogs can easily be infected experimentally with *Borrelia duttoni*

The multimammate rat is a wild rodent which live in close contact with man in Africa, and in the native villages it plays the same part as the house ra (*Rattus rattus*) and the Norwegian rat (*Rattus norvegicus*) in the towns in Africa and in human habitation throughout Europe and Asia Tampans brought t the huts by native hunters, for example, sooner o later come into contact with the multimammate rat there Is this rat perhaps the natural reservoir, o one of them, of *Borrelia duttoni* ? We have not ye looked for natural infections in this rat, but th experimental picture shows that it would be an idea reservoir, as it remains highly positive for a long time without its general condition of health being influenced This problem is being investigated mor thoroughly

I wish to thank Prof J F Murray and Dr B d Meillon of this Institute for their interest and help Mr D H S Davis, Medical Ecology Centre, Union Health Department, for providing the wild rodents and Drs B T Squires, B O Wilkin and E I Szlamp of the Medical Department, Bechuanalan Protectorate, for their support The photomicro graphs were prepared by Mr M Ulrich of the Photo graphic Department, South African Institute fo Medical Research

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[1] Geigy, R , and Mooser, H , *J Trop Med Hyg* , **58,** 199 (1955)

CHEMISTRY AND TAXONOMY IN THE DIPTEROCARPACEAE

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LIVING specimens of the Dipterocarpaceae are not apparently available in Great Britain, and it has so far not been possible to include them in surveys of the phenolic constituents of plants[1-3] Recently, however, through the kindness of the Director, Forest Research Institute, Kepong (Selangor), fresh leaves of twenty-eight species of dipterocarps have been received from Malaya, and these have been examined by the methods previously described (*loc cit*) The results are interesting because the species were selected from a large collection so as to be representative not only of all the available genera but also of the recognized groups of *Shorea*, the largest genus in this family, which, because of its valuable timber and other economic products, has received a great deal of attention from the forestry officers and official taxonomists in the Indomalaysian countries

Consideration of the phenolic constituents of the leaves of a large number of Dicotyledons has indicated[3] that three characters are particularly valuable from the taxonomic point of view presence or absence of leuco-anthocyanins; presence or absence of vicinal trihydroxy groupings in the phenolic constituents, and the presence or absence of the polyhydroxy and hydroxymethoxy aromatic acids, caffeic, ellagic, ferulic and sinapic acids. It is often of value also to note other constituents, not necessarily identified, which are present in some, but absent from other, species in the same or different genera, as indicators of possible relation between the species possessing them

The results of the chromatographic examination of the hydrolysates of the leaves of the 28 species are given in Table 1 The constituents recorded are, from left to right, in order of increasing R_F in aqueous acetic acid–hydrochloric acid (Forestal solvent), *M* = myricetin, *D* = delphinidin (formed from leucodelphinidin), *E* = ellagic acid, *Q* = quercetin, *Cy* = cyanidin (formed from leucocyanidin), *K* = kaempferol, *Caff* = caffeic acid, *S* = sinapic acid, *F* = ferulic acid In the last column are recorded other constituents visible in the ultra-violet, with their R_F values in Forestal solvent and their appearance in ultra-violet before and after (→) fuming in ammonia vapour The abbreviations used are *bl* = blue, *brn* = brown, *gr* = green, *V* = violet, *y* = yellow, *br* = bright, *d* = deep, *dk* = dark, *f* = faint, *l* = light, *v* = very Sinapic acid and ferulic acid are identified on a separate chromatogram run in toluene–acetic acid[4]

The genera are listed in the order given by Symington[5] The species are listed in alphabetical order within the genus, except for *Shorea* which is divided into groups according to the same author Symington considered these groups to be natural subdivisions of the genus, perhaps worthy of generic status, but was not prepared to give them definite botanical names or status until the whole genus was revised taxonomically This revision has still not been made for it awaits the collection and description of the rich Bornean dipterocarp flora Desch[6,7], working on the timbers of *Shorea*, independently established four groups based mainly on gross timber characters which correspond closely to Symington's subdivisions The groups are named *B* = balau, *Y*, *W* and *R* = yellow, white and red meranti respectively; within each there is considerable homogeneity in characters of the living trees, including the colour of the wood and sliced bark and the dead leaves

Table 1

Species	Div	*M*	*D*	*E*	*Q*	*Cy*	*K*	*Caff*	*S*	*F*	Other constituents
Shorea foxworthyi Sym	*B*	−	+	+	−	?	−	−	(+)	−	→ *d* purple-*brn*, cf gallic acid, 0 61
,, *kunstleri* King	*B*	−	−	?	+	+	+	−	(+)	−	→ dull *y*, 0 73
,, *maxwelliana* King	*B*	(+)	−	+	−	+	−	−	(+)	−	*bl* -*V* → *br gr*, 0 69, *bl* -*V* → *l*, 0 9
,, *maxima* (King) Sym	*Y*	−	−	+	−	?	+	?	(+)	−	*bl* -*V* →*v br bl* -*gr*, 0 73
,, *multiflora* (Burck) Sym	*Y*	−	−	++	−	(+)	+	?	−	−	intense *br bl*, 0 69, *V*, 0 8
,, *bracteolata* Dyer	*W*	−	−	+	+	+	+	−	−	−	
,, *curtisii* Dyer ex King	*R*	+	+	?	+	(+)	−	−	−	−	
,, *hemsleyana* (King) King ex Foxw	*R*	−	−	+	−	−	−	+	−	−	→ *y*, 0 77
,, *leprosula* Miq	*R*	−	+	?	−+	++	+	−	−	−	
,, *singkawang* (Miq) Burck	*R*	−	+	−	−	−	−	−	−	−	→ *f y*, 0 7
Hopea beccariana Burck		+	−	+	+	−	+	+	−	−	*bl* -*V* → *br gr*, 0 7
,, *mengarawan* Miq		−	−	++	−	−	−	−	+	+	
,, *nutans* Ridl		−	−	+	+	−	−	−	(+)	−	*v d bl* → *v br bl*, 0 68
,, *odorata* Roxb		−	−	+	−	−	−	++	−	−	*v d bl* → *v br bl*, 0 68
,, *sangal* Korth		−	−	+	−	−	−	++	−	−	
,, *subalata* Sym		−	−	+	(+)	−	−	?−	−	−	intense *br bl*, 0 72
Balanocarpus heimii King		−	−	+	−	−	−	++	−	−	
Dipterocarpus baudii Korth		+	+	+	−	+	−	−	−	−	
,, *costulatus* V Sl		++	+	?	+	−	−	−	−	−	
,, *crinitus* Dyer		+	+	+	−	−	−	−	−	−	
,, *kerrii* King		++	+	−	+	(+)	−	−	−	−	
Dryobalanops aromatica Gaertn *f*		+	+	+	(+)	+	−	−	−	−	
,, *oblongifolia* Dyer		+	+	+	−	+	−	−	−	−	
Anisoptera laevis Ridl		−	−	−	−	−	+	−	−	(+)	greenish, 0 86
Vatica nitens King		+	+	−	−	+	−	−	(+)	−	
,, *stapfiana* (King) V Sl		−	−	+	−	−	−	−	+	−	*V* → *y*, 0 61
,, *wallichii* Dyer		−	−	++	−	−	−	−	(+)	−	*dk* → dull *y*, 0 79
Upuna bornensis		−	−	−	−	−	−	−	−	−	*gr*, 0 79

The data in Table 1 suggest that the genera can be arranged in groups, in the first instance according to the abundance and type of the leuco-anthocyanins present *Dipterocarpus* and *Dryobalanops*, abundant with consistent *L–D*, *Shorea* (and one *Vatica* sp) less abundant, with both *L–D* and *L–Cy*, *Hopea*, *Balanocarpus*, *Anisoptera*, and two *Vatica* spp with little or no *L–A*, and *Upuna* with none of the common phenolic constituents

Dipterocarpus and *Dryobalanops* agree also in having consistent and often abundant myricetin, and no subsidiary constituents In both *Shorea* and *Hopea* many of the species have a subsidiary constituent R_F 0 68–0 7 with intensely blue fluorescence, which may or may not be the same in all species These two genera have also numerous other subsidiary constituents *Hopea*, *Balanocarpus*, and one or two *Shorea* spp also have caffeic acid, absent from the other genera All the genera except *Anisoptera* and *Upuna* have ellagic acid, *Shorea foxworthyi* having in addition (probably) gallic acid

Overall the grouping suggested is *Dipterocarpus* with *Dryobalanops*, *Shorea* with *Hopea* and *Balanocarpus*, *Vatica* rather closer to *Shorea* than to *Hopea*, *Anisoptera* and *Upuna* uncertain

The groups of *Shorea* are not very distinct, neither yellow nor white meranti have much *L–A*, and *L–D* is absent from both sections, but species in both the balau and the red meranti groups have the same constitution The nature of the pigments responsible for the colours of the sliced bark is unknown, it is not even known whether they are phenolic, so that there is no *prima facie* reason to expect that the phenolic constituents in the leaves would follow the proposed subdivision of the genus

One further point is worth making *Balanocarpus* Bedd has become a repository for all wingless fruited dipterocarps *B heimii* should probably be included in *Hopea* on floral characters[5] and wood characters[6], and now we can reach the same conclusion from the chemistry The suggested regrouping of other species is also supported by the present evidence

[1] Bate-Smith, E C, *Sci Proc Roy Dublin Soc*, **27**, 165 (1956)

[2] Bate-Smith, E C, and Metcalfe, C R, *J Linn Soc* (*Bot*), **55**, 669 (1957)

[3] Bate-Smith, E C (in preparation)

[4] Bate-Smith, E C, *Chem and Indust*, 1457 (1954)

[5] Symington, C F, "Foresters' Manual of Dipterocarps", *Malay For Rec*, No 16 (1941)

[6] Desch, H E, "Commercial Timbers of the Malay Peninsula (1) The Genus *Shorea*", *Malay For Rec*, No 12 (1936)

[7] Desch, H E, "Dipterocarp Timbers of the Malay Peninsula", *Malay For Rec*, No 14 (1941)

PLANT-GROWTH SUBSTANCES AND THE COPPER CHELATION THEORY OF THEIR MODE OF ACTION

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FOLLOWING the observations that certain compounds possessing chelate groups can exhibit significant plant growth-regulating activity[1], several workers have been trying to demonstrate the converse, namely, that highly active plant-growth regulators can react with metal ions to form chelate complexes The discovery by Cohen, Ginzburg and Heitner-Wirgum[2] that the ultra-violet absorption spectra of 3-indolylacetic acid and 1-naphthylacetic acid are profoundly altered in presence of cupric, but not calcium or magnesium ions, led them to postulate that the cupric ion reacted with the carboxyl group in these acids to form a copper complex which then formed a chelate by employing the aromatic ring as the second complexing group

After repeating their experiments using solutions obtained by dissolving cupric nitrate trihydrate in 50 per cent aqueous ethanol, I observed that with 3-indolylacetic acid the optical density of each solution in the series measured at 360 mμ did not remain constant but tended to increase slowly (cf ref 3) Since with cupric nitrate and 1-naphthylacetic acid, measured at 330 mμ, the optical density of each solution remained constant for several minutes, this system was used for comparison with the cupric nitrate/1-naphthoic acid system measured at 348 mμ It was found that the relationship between optical density and acid/copper ratio is similar for both 1-naphthylacetic acid (Fig 1) and 1-naphthoic acid Thus, the enhancement of ultra-violet absorption is not limited to the highly active 1-naphthylacetic acid but occurs also with the relatively inactive 1-naphthoic acid

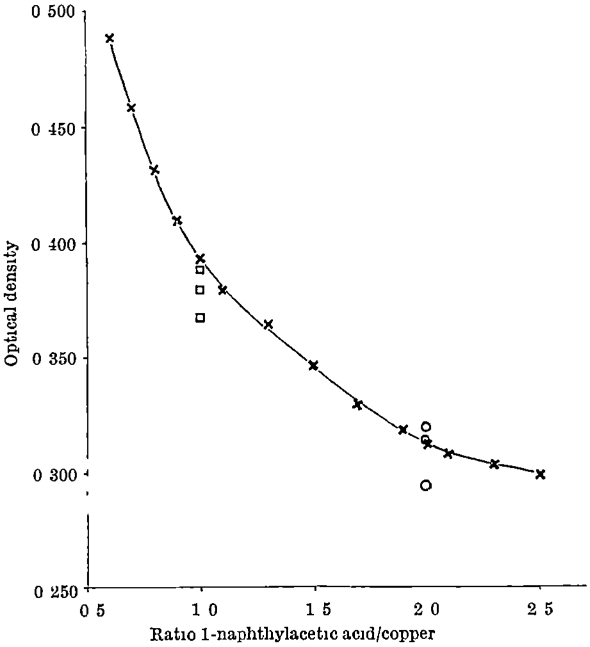

Fig 1 Optical density of copper/1-naphthylacetic acid complex (330 mμ, 1 cm cells, *p*H ~ 3 6) in 50 per cent aqueous ethanol ×, Concentration of added cupric nitrate varied as shown with concentration of 1-naphthylacetic acid constant at 2 × 10^{-2} *M*, ○, concentrations of added copper 1-naphthylacetate 10^{-2} *M* and nitric acid 2 × 10^{-2} *M*, ⊡, concentrations of added copper 1-naphthylacetate 10^{-2} *M*, nitric acid 2 × 10^{-2} *M* and cupric nitrate 10^{-2} *M*

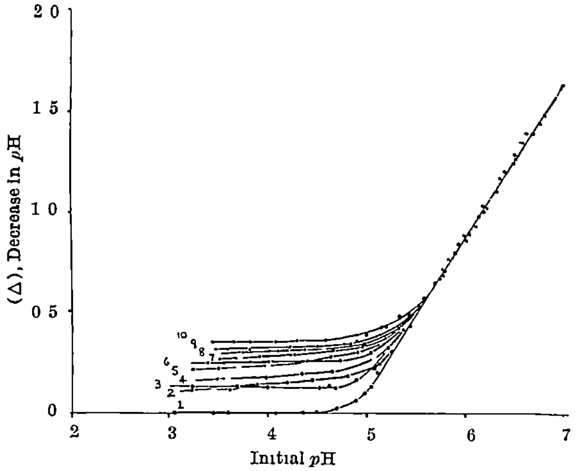

Fig. 2. The relationship between the initial pH of 50 per cent aqueous ethanol, containing the acid indicated, and the decrease in pH, (Δ), on dissolving 4·83 mgm. cupric nitrate trihydrate in 10 ml. Acids added to obtain initial pH: 1, nitric; 2, formic; 3, 2,4-dichlorophenoxyacetic; 4, 1-naphthoic; 5, succinic; 6, benzoic; 7, acetic; 8, 1-naphthylacetic; 9, 3-indolylacetic; and 10, trimethylacetic acid

The general reaction in aqueous ethanol between cupric nitrate and 1-naphthylacetic acid can be written:

$$2C_{10}H_7CH_2COOH + Cu(NO_3)_2 \overset{\text{(50 per cent aqueous ethanol)}}{\rightleftharpoons} Cu(C_{10}H_7CH_2COO)_2 + 2HNO_3$$

In writing this equation the various ionic species which may exist in solution have, for simplicity, not been characterized. For each 1-naphthylacetic acid/copper ratio the optical density of the solution at constant temperature should be independent of whether the equilibrium is attained by using reactants which give the forward reaction or reactants which give the reverse reaction. Accordingly, cupric 1-naphthylacetate was synthesized and used stoichiometrically with nitric acid in aqueous ethanol to give the reverse reaction and reconstitute the solution having a ratio 1-naphthylacetic acid/copper equal to 2·0. The optical density of this solution in which the reverse reaction had occurred was found to be identical with that of the solution containing the products of the forward reaction (Fig. 1). Furthermore, addition of cupric nitrate, sufficient to lower the 1-naphthylacetic acid/copper ratio to 1·0 in these reconstituted solutions, increased the optical density to the value found for this ratio when using the reactants of the forward reaction (see Fig. 1). Since the equilibrium may be reached from either side without adding a chelate group, it is concluded that a reaction involving chelation is not required to account for the exaltation of ultra-violet absorption given by cupric nitrate with 1-naphthylacetic acid.

By measuring the pH Cohen *et al.*[2] also confirmed that cupric nitrate reacted differently from calcium and magnesium nitrates when added to solutions of 3-indolylacetic acid and 1-naphthylacetic acid in aqueous ethanol. Furthermore, they found that while the pH of these acids in solution was lowered due to release of hydrogen ions by complexing of the copper ion with the carboxyl group, yet under the same conditions only slight complexing occurred with acetic acid or indole. The results were interpreted as evidence for the entire aromatic ring functioning as a second complexing group, thus resulting in chelate formation.

In a study using aqueous ethanol solutions of several closely related acids, comprising active and inactive growth regulators, it was found that in general the addition of cupric ions lowers the pH. Some of the results are shown in Fig. 2. The observed pH changes, however, do not correlate with plant growth-regulating activity; thus, the aromatic carboxylic acids (for example, benzoic and 1-naphthoic), and the alkanecarboxylic acids (for example, formic, acetic and trimethylacetic), which are all inactive[4] in the wheat cylinder elongation test, exhibit an effect in presence of copper ions similar to that found with highly active[4] 3-indolylacetic acid, 1-naphthylacetic acid and 2,4-dichlorophenoxyacetic acid. Furthermore, the results show no difference which would indicate the occurrence of chelation involving the aromatic ring (Fig. 2).

In the pH range studied two mechanisms of hydrogen ion formation are apparent. Mechanism I, which operates over a pH region known to be of considerable physiological importance in plant cells, produces a large effect (Δ), which is the same for all the different compounds examined (Fig. 2). It is significant that at higher initial pH values, that is, when the concentration of carboxylic acid for adjusting the pH is decreasing, the effect (Δ) obtained by adding the copper salt is increasing linearly; and when no carboxylic acid is added to the aqueous ethanol solvent the effect (Δ) is the largest throughout the pH range investigated. The results lead to the conclusion that the effect (Δ) between pH 5·4 and 7 depends upon hydrolysis and they indicate that hydrogen ion formation occurs by a reaction of the following type:

$$[Cu(H_2O)_x]^{++} \rightleftharpoons [Cu(OH)(H_2O)_{x-1}]^{+} + H^{+} \qquad (I)$$

The cupric ion is represented here as described by Orgel, and the reaction written by analogy with his example for iron[5]. On the other hand, mechanism II appears limited to the pH region below about 5·4. The effect (Δ) is smaller, different for the different structures examined, and zero for nitric acid. There appears to be a correlation between the effect (Δ) and the *pK* value of each acid and further work on this aspect is proceeding. The results suggest that hydrogen ion formation by mechanism II depends upon salt (that is, complex) formation, which,

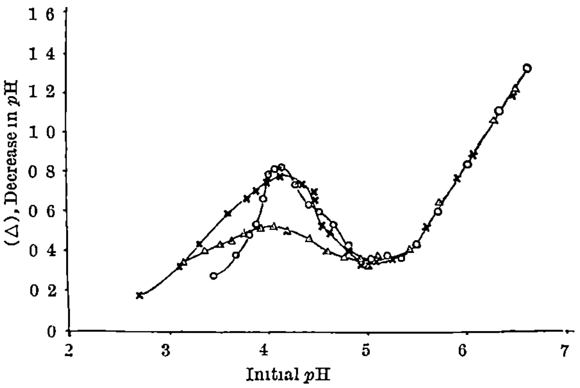

Fig. 3. The relationship between the initial pH of 50 per cent aqueous ethanol, containing the acid indicated, and the decrease in pH, (Δ), on dissolving 4·83 mgm. cupric nitrate trihydrate in 10 ml. Acids added to obtain initial pH: ○, aspartic; Δ, glycollic and ×, citric acid

ignoring hydration, can be represented by an ionic reaction of the type

$$n\mathrm{H}A + \mathrm{Cu}^{++} \rightleftharpoons \mathrm{Cu}(A)_n^{[2-n]+} + n\mathrm{H}^+ \qquad \text{(II)}$$

where HA is a weak acid and n is 1 or 2 Thus, these results from pH measurements in the region pH 3–5 4 can be interpreted by an equation which is an ionic form of the general reaction shown above to account for the results obtained by ultra-violet absorption determinations

When certain carboxylic acids (for example, glycollic, citric and aspartic) were examined, in aqueous ethanol with cupric nitrate, it was found that another operative factor could be demonstrated (see Fig 3) It is clear, therefore, that these acids which have the ability to form chelates with copper[6] exhibit behaviour different from the various plant-growth substances studied

Thus, the present evidence does not support the concept that plant-growth regulating activity is explicable in terms of chelation (cf ref 7)

I am grateful to Prof R S Nyholm and Prof R L Wain for helpful discussions

[1] Bennet-Clark, T A, "The Chemistry and Mode of Action of Plant Growth Substances" (Butterworth Publications, London, 1956) Heath, O V S, and Clark, J E, *Nature*, **177**, 1118 (1956) Weinstein, L H, Meiss, A N, Uhler, R L, and Purvis, E R, *Nature*, **178**, 1188 (1956)

[2] Cohen, D, Ginzburg, B-Z, and Heitner-Wirguin, C, *Nature*, **181**, 686 (1958)

[3] Recaldin, D A, and Heath, O V S, *Nature*, **182**, 539 (1958)

[4] Fawcett, C H, Wain, R L, and Wightman, F, *Nature*, **178**, 972 (1956) Wain, R L, and Wightman, F, *Proc Roy Soc*, B, **142**, 525 (1954), and unpublished results

[5] Orgel, L E, "Metals and Enzyme Activity" (Biochemical Society Symposia No 15 Cambridge University Press, 1958)

[6] Martell, A E, and Calvin, M, "Chemistry of Metal Chelate Compounds" (Prentice-Hall, New York, 1952)

[7] Armarego, W L F, Canny, M J, and Cox, S F, *Nature*, **183**, 1176 (1959)

CONTROL OF ANTHERIDIUM FORMATION IN THE FERN SPECIES *ANEMIA PHYLLITIDES*

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DÖPP[1] demonstrated that an extract from mature prothalli of *Pteridium aquilinum* hastened the onset of antheridium formation in young prothalli of this fern species by a few days and in the prothalli of *Athyrium filix-mas* by a few weeks Dopp envisaged the possibility that the promotion of antheridium formation occurred by way of unspecific growth inhibition Subsequent investigations, though, led to the conclusion that the activity of the extract must be attributed to a specific factor which controls the initiation of antheridia during the normal process of development[2,3]

An assay was devised which took advantage of the observation that the prothalli of *Onoclea sensibilis* failed to form any antheridia spontaneously under the prevailing conditions of culture but responded readily when grown on a medium containing extract of mature *Pteridium* prothalli Conditions were further defined under which the extract from seven-week-old prothalli of *P aquilinum* was active to a dilution of 1 30,000 This increased the activity obtained by Dopp by a factor of about 300 Under these same conditions of culture the active substance accumulated to almost as high an activity in the medium[2]

While the prothalli of both *O sensibilis* and *P aquilinum* responded readily to the active factor at young stages of development, they lost their responsiveness soon after they assumed heart shape and a few days prior to attaining the archegonial phase Once insensitive, the prothalli failed to form antheridia even if supplied with the factor at a concentration 15,000 times higher than that sufficient to induce antheridia in prothalli just a few days younger[3]

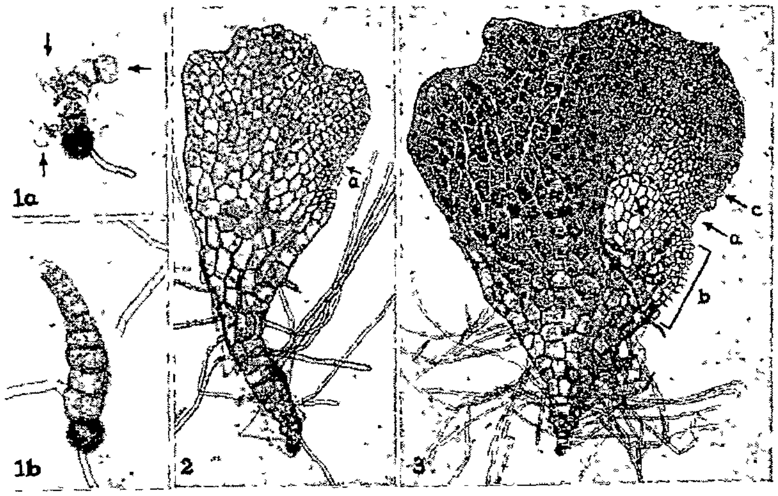
Work on the activity spectrum of this factor disclosed that it was active toward the representatives tested of seven out of nine sub-groups of the family Polypodiaceae listed by Eames[4] the asplenioids, pteroids[1], onocleoids, blechnoids, dryopteroids[2], gymnogrammoids[5] and toward *Woodsia obtusa*, a representative of the sub-group woodsioids (unpublished information) Among non-polypodiaceous species, only *Dennstaedtia punctilobula* (Dicksoniaceae) was found to be responsive The substance failed to promote antheridium formation even at the highest available concentration (half full-strength *Pteridium* medium that was active toward the prothalli of *O sensibilis* to a dilution of 1 30,000) in the following fern species *Polypodium aureum* (Polypodiaceae), *Lygodium japonicum*, *Anemia phyllitides* (Schizaeaceae), *Osmunda claytonia* and *O cinnamomea* (Osmundaceae)

The present account deals with the control of antheridium formation in *Anemia phyllitides*, one of these unresponsive fern species

The procedures used in the sterilization and inoculation of the spores have been described elsewhere[3] A detailed description of the conditions of culture and of the medium which contains the inorganic salts used by Moore[6] is given in the same report Hoagland's earlier used *A–Z* solution of micro-elements was replaced with a Hoagland trace element solution of simpler composition (mgm /l of medium boric acid, 2 86, manganese chloride ($\mathrm{MnCl_2\ 4H_2O}$), 1 81, zinc sulphate ($\mathrm{ZnSO_4\ 7H_2O}$), 0 22, molybdenum trioxide, 0 07, copper sulphate ($\mathrm{CuSO_4\ 5H_2O}$), 0 08) Iron was added as ferric tartrate The prothalli were cultured in 125-ml flasks containing 33 ml of medium or in 50-ml flasks with 12 ml of nutrient Unless stated otherwise, the media were solidified with 1 per cent agar

It was observed that prothalli of *Anemia phyllitides* formed antheridia at a very early stage of development, while they were still at the filamentous phase, if the spores were inoculated on 35–50-day-old gametophyte cultures of the same fern species Prothalli superinoculated on 30-day-old cultures attained the antheridial phase somewhat later, although still many days prior to the control prothalli

In a subsequent experiment a single 50-day-old gametophyte of *Anemia phyllitides* was placed on the agar surface at one side of a seven-day-old culture of this same species in 125-ml flasks Observations at



Figs 1–3 (Fig 1*a* and *b*, × 62, Fig 2, × 27 5, Fig 3, × 20)

daily intervals disclosed that young prothalli with antheridium initials could be detected within 3–4 days in the immediate proximity of the mature prothallus 7–8 days following the introduction of the mature gametophyte at the side of the flasks, young antheridium-bearing prothalli could be first observed in the centre, and 12–14 days after its introduction at the opposite side of the flask 8–10 further days elapsed before antheridium initials appeared in the control cultures The above observations suggested that, as the prothalli of *A phyllitides* reached a certain stage of development, they began to elaborate, and to secrete into the medium, a substance controlling the induction of antheridia This hypothesis gained in likelihood when medium that had supported the growth of *Anemia* prothalli was assayed for antheridium-inducing activity The assays were conducted by inoculating spores of *A. phyllitides* on fresh nutrient medium which contained the medium of the *Anemia* cultures at a dilution series with a dilution factor of approximately 3 (1/3, 1/10, 1/30, 1/100,) 50-ml flasks which contained 12 ml of medium were used The assays were read 18 days after inoculation, 11–12 days prior to the onset of spontaneous antheridium formation Medium of 29-day-old or younger cultures was regularly inactive even at 1/3 full strength, the highest concentration of *Anemia* medium tested On the other hand, the medium of 39-day-old cultures induced antheridia to a dilution of 1 30, the medium of 49- and 59-day-old cultures to a dilution of 1 100 (occasionally 1 300), and 1 300, respectively The same activity was encountered in liquid and agar-solidified media Whereas the lowest effective concentration of *Anemia* medium brought about antheridium formation in only 1 out of 4–20 prothalli, the percentage of responding prothalli rose to 100 as the concentration of the active factor was increased by a factor of 3–10 Antheridium initials could be first discerned about 9 days after the spores were inoculated (the bulk of the spores germinated between 3 and 5 days following inoculation) It was further noticed that activity could be regularly detected at a concentration lower by a factor of about 3 if the assay was read 18 instead of 12 days following inoculation The reason for this remains to be explored Fig 1*a* shows a 12-day-old *Anemia* prothallus with 3 antheridia (see arrows) which were initiated in response to 1/30 full strength *Anemia* medium (active to a dilution of 1 300), while control prothalli in cultures of the same age (Fig 1*b*) and even in 25-day-old cultures (Fig 2) were invariably free of antheridia

Figs 2 and 3 show further that the maturing prothallus has a lateral meristem (arrow *a*), a phenomenon encountered in only a few fern species[7] The first spontaneously formed antheridium, which would probably have arisen on the prothallus pictured in Fig 2 in about 4–5 days, is invariably initiated from a marginal cell a short distance behind the meristematic initial Marginal cells afterwards cut off by the meristematic initial toward the base of the prothallus also give rise to antheridia so that ultimately a whole row of them can be seen (marked *b* in the 35-day-old prothallus of Fig 3) In contrast, the marginal cells cut off by the initial toward the tip of the prothallus fail to form antheridia even in the presence of added *Anemia* factor Instead, some of them give rise to hook-shaped hairs (Fig 3, arrow *c*) Once the first antheridium initial has been formed marginally, others arise on cells inside the prothallus (3 of about 18 such antheridia are indicated by arrows)

The area of spontaneous antheridium formation always remains restricted, however Thus, antheridia never arise in the part of the prothallus anterior to the lateral meristem Again, the zone of antheridium formation in the posterior region does not stretch across the whole prothallus , instead, it extends about halfway or less inside the prothallus from the margin of the cell plate which bears the lateral meristem (the zone is marked by a black broken line on Fig 3) The other half of the posterior region remains free of antheridia except for the occasional occurrence of 1–3 antheridia in marginal cells

Observations following the application of the active substance to cultures of various ages showed that young prothalli responded with antheridium formation throughout most of their body As the age of the prothalli increased, the responding area gradually contracted to that described for spontaneous antheridium formation The loss of sensitivity in the anterior part of the prothallus preceded the contraction in the responsive area of its posterior region

Information was obtained concerning the time lag between the application of the active substance and the first detection of antheridium initials Liquid medium of 50-day-old *Anemia* cultures (active to 1 300) was applied to 12-day-old and to 18-day-old *Anemia* cultures which were grown in 50-ml flasks containing 12 ml of agar-solidified nutrient $\frac{1}{2}$ ml of the *Anemia* medium was applied to each flask, to some at full strength, to others at dilutions of $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$ and 1/16 The control cultures received an equal amount of fresh medium Antheridium initials (semicircular outgrowths of vegetative cells that were not as yet cut off by a cell wall) first appeared between 1 and $1\frac{1}{2}$ days following the application of the active substance and in the 18-day-old cultures In contrast, the appearance of antheridium initials in both 6- and 9-day-old prothalli of

O sensibilis followed the application of the *Pteridium* factor with a delay of between 2½ and 3 days at all tested concentrations

The first-formed *Anemia* initials attained the four-cell stage, that is, the number of cells contained by mature antheridia, between 3½ and 4 days after the active substance was applied No difference could be detected between the rates at which the first-formed antheridium initials attained the four-celled stage over the applied range of concentrations On the other hand, an increase from 1/16 to ½ full strength of the added *Anemia* medium increased the proportion of responding prothalli from about 15 to 100 per cent If the *Anemia* factor was supplied to 5-day-old prothalli which comprised a maximum of 3 green vegetative cells, then between 3 and 3½ days elapsed before the first antheridium initials could be seen, that is, about 2 days more than in both the 12-day-old and the 18-day-old prothalli It thus appears that the events leading to the appearance of antheridium initials proceed more slowly in very young prothalli Alternatively, the very young prothalli may lack competence to respond to the active factor

As indicated above, the *Pteridium* factor brings about antheridium formation in a large number of fern species It should also be emphasized, though, that the minimally effective concentrations vary so widely that the prothalli of some species (for example, *Dennstaedtia punctilobula*) must be supplied with that factor at a concentration more than a hundred times higher than those of other species (for example, *Onoclea sensibilis*) The possibility must thus be considered that the induction of antheridia in *O sensibilis* and in *A phyllitides* is controlled by the same factor at different ranges of effective concentrations *Pteridium* medium (active toward the prothalli of *O sensibilis* to a dilution of 1 30,000) was inactive toward the prothalli of *A phyllitides* at all concentrations which, with a dilution factor of 3, ranged from ⅓ to 1/100,000 full strength In turn, the prothalli of *O sensibilis* were unresponsive toward *Anemia* medium (active toward the prothalli of *A phyllitides* to a dilution of 1 300) at all dilutions which ranged again from ⅓ to 1/100,000 full strength

It is, therefore, difficult to avoid the conclusion that the induction of antheridia in *A phyllitides* and in *O sensibilis* is controlled by chemically distinct substances This conclusion receives support from the demonstration that the antheridium-inducing activity of the *Anemia* medium is stable to boiling for 10 min at *p*H 12, while the *Pteridium* factor was labile under those conditions[2] The antheridium-inducing activity of the *Anemia* medium was further found to be stable to boiling for 10 min at *p*H 2 and to autoclaving at *p*H 5 4, the *p*H of the culture medium , it was destroyed upon ashing and adsorbed on charcoal The latter properties are similar to those of the *Pteridium* factor[2]

The *Anemia* factor failed to promote antheridium formation in prothalli of *Osmunda claytonia* (checked 15 days after inoculation, 2 days prior to the onset of spontaneous antheridium formation), which were also unresponsive to the *Pteridium* factor The prothalli of *Lygodium japonicum*, another species unresponsive toward the *Pteridium* factor, were shown to elaborate, and to secrete into the medium, a substance which greatly hastens the onset of the antheridial phase in this fern species which, like *A phyllitides*, belongs to the family Schizaeaceae Preliminary investigations indicate that this substance is chemically distinct both from the *Pteridium* factor and from the *Anemia* factor

It is apparent from these studies that antheridium formation is controlled by different substances in different groups of ferns It should also be recalled that within the wide range of species responsive to the *Pteridium* factor, the minimally effective concentrations vary widely Thus, the prothalli of *Dennstaedtia punctilobula* failed to respond unless they were supplied with the *Pteridium* factor at a concentration about 125 times higher than was necessary to induce antheridia in prothalli of *O sensibilis* In the prothalli of *Woodsia obtusa* the minimally effective concentration of the *Pteridium* factor exceeded that required for antheridium formation in the prothalli of *O sensibilis* by a factor of about 25 The possibility must therefore be considered that the factors controlling antheridium formation in these species are actually different but structurally so closely related that the factor produced by *P aquilinum* is capable of bringing about antheridium formation also in *Dennstaedtia punctilobula* and in *Woodsia obtusa* if it is supplied at a high enough concentration Raper[8] also considers the possibility that hormonal specificities account for the failure to obtain oospores in some of the attempted inter-species and intergeneric crosses of water moulds

The above results raise a question of biological specificity The work of Kluyver and Van Niel has directed attention to the similarity, even identity, of many basic biochemical patterns in taxonomically widely separated organisms It is tempting to postulate that the metabolism associated with antheridium formation, an event that we conceive of mainly in morphological terms, is also similar in different fern species The above results may be reconciled with such a postulate if we consider that the induction of an antheridium is likely to involve many reactions and compounds Antheridium formation in *P aquilinum* might thus be controlled by a different factor than in *A phyllitides* because a different reaction became rate-limiting during evolution Alternatively, we might be witness to evolution on a molecular level On this assumption the *inducing* molecule has undergone a gradual structural modification probably concomitantly with changes in a receptor molecule The isolation and characterization of the two substances should yield pertinent information In the meantime, an attempt is being made to assay for similarity between the two factors based on the postulate that one factor might be a precursor of the other or that one factor might behave as a chemical analogue of the other and thus interfer with its synthesis or with the function it perform in the initiation of antheridia

I am grateful to Dr Armin C Braun for th encouragement he has given this investigation an for a critical reading of the manuscript I am als indebted to Drs Ralph H Wetmore and Max War for supplying plants and spores of *A phyllitides*

This investigation was supported in part by National Science Foundation Research Grant (*G*-3225

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[1] Dopp, W , *Ber deut Bot Ges* , **63**, 139 (1950)

[2] Näf, U , *Growth*, **20**, 91 (1956)

[3] Näf, U , *Physiol Plantarum*, **11**, 728 (1958)

[4] Eames, A J , "Morphology of Vascular Plants Lower Group (McGraw-Hill, New York and London, 1936)

[5] Dopp, W , *Ber deut Bot Ges* , **72**, 11 (1959)

[6] Moore, G T , *J App Micro and Lab Methods*, **6**, 2309 (1903)

[7] Stokey, A G , and Atkinson, L R , *Phytomorphol* **2**, 1 (1952)

[8] Raper, J R , *Bot Gaz* , **112**, 1 (1950)

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, November 2

Institution of Electrical Engineers, Electronics and Communications Section (at Savoy Place, London, W C 2), at 5 30 p m —Dr A E Karbowiak "Some Comments on the Classification of Waveguides Modes", Mr L Lewin "Some Comments on Quasi-Optical Methods at Millimetre Wave-lengths"

University of London (at the School of Oriental and African Studies, London, W C 1), at 5 30 p m —Prof A de Almeida (Lisbon) "Mucuepes—a Native People from the Moçâmedes Desert" (First of three lectures on "The Non-Bantu Peoples from Angola" Further Lectures on November 3 and 5)*

Society of Chemical Industry, London Section (at 14 Belgrave Square, London, S W 1), at 6 30 p m —Dr Otto Horn "Chemical Research in Germany"

Tuesday, November 3

University of London (in the Anatomy Theatre, University College, Gower Street, London, W C 1), at 1 15 p m —Mr N J B Plomley "The Tasmanians an Extinct Race" *

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W C 2), at 5 30 p m —Mr P Gleghorn "An Analogue Electronic Multiplier using Transistors as Square-Wave Modulators"

University of London (at Imperial College of Science and Technology, London, S W 7), at 5 30 p m —Prof E C Cherry "Telecommunication as Social Science" (Inaugural Lecture)

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W C 1), at 5 30 p m —Dr J M Mitchison "The Life Cycle of Growing Cells" (Sixth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation Further lectures on November 5, 10, 12, 17, 19, December 1, 3, 8, 10)

Plastics Institute (at the Wellcome Building, 183–193 Euston Road, London, N W 1), at 6 30 p m —Dr W F Watson "Recent Advances in Synthetic Rubbers"

Society of Chemical Industry, Plastics and Polymer Group (at 14 Belgrave Square, London, S W 1), at 6 30 p m —Dr G F C Barrett " 'Delrin' Acetal Resin"

Textile Institute (at the Chemical Society, Burlington House, Piccadilly, London, W 1), at 6 30 p m —Mr J David "Modern Proofing"

Wednesday, November 4

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W C 1), at 3 p m and 6 p m —Half-day Symposium on "Input/Output Devices"

Institute of Petroleum (at 61 New Cavendish Street, London, W 1), at 5 30 p m —Mr W S Ault "Oil and Transport"

Royal Meteorological Society (at 49 Cromwell Road, London S W 7), at 5 30 p m —Mr H Charnock "Ocean Currents"

Society for Analytical Chemistry (at the Chemical Society, Burlington House, Piccadilly, London, W 1), at 7 p m —Meeting for reading of Original Papers

Thursday, November 5

University of London (at the Postgraduate Medical School of London, Ducane Road, London, W 12), at 4 p m —Dr T Alper Dr M Ebert and Dr R H Thomlinson "Biological Effects of Radiation—General Survey" (First of six lectures Further lectures on November 12, 19, 26, December 3 and 10)*

Royal Society (at Burlington House, Piccadilly, London, W 1), at 30 p m —Prof A V Hill, F R S , and Mr J V Howarth "The Reversal of Chemical Reactions in Contracting Muscle During n Applied Stretch", Mr F W Darwin and Dr J W S Pringle, F R S "The Physiology of Insect Fibrillar Muscle 1 Anatomy and nnervation of the Basalar Muscle of Lamellicorn Beetles", Mr C E Machin and Dr J W S Pringle, F R S "The Physiology f Insect Fibrillar Muscle 2 Mechanical Properties of a Beetle Flight Muscle"

University of London (in the Physiology Theatre, University ollege, Gower Street, London, W C 1), at 5 p m —Dr P N Campbell The Synthesis of Protein by the Cytoplasmic Components of Animal ells" (First of three lectures Further lectures on November 12 nd 19)*

Institution of Electrical Engineers (at Savoy Place, London, W C 2), at 5 30 p m —Mr M C Crowley-Milling "The Application of Irradiation in Industry"

University of London (at the London School of Hygiene and ropical Medicine, Keppel Street, Gower Street, London, W C 1), at 30 p m —Prof G Pontecorvo "Genetic Analysis via Somatic Cells" (Seventh of fifteen lectures on "The Scientific Basis of Medine" organized by the British Postgraduate Medical Federation urther lectures on November 10, 12, 17, 19, December 1, 3, 8, 10)*

Society of Chemical Industry, Microbiology Group (joint eeting with the Agriculture Group, at 14 Belgrave Square, London, W 1), at 6 15 p m —Dr M E Brown "Plant Roots and Soil Micro-Organisms", Dr R M Jackson "The Ecological Significance of the Rhizosphere"

Friday, November 6

Institute of Physics (at 47 Belgrave Square, London, S W 1), at 6 p m —Mr R D Moore "The Role of Physics in the Investigation and Treatment of Heart Disease"

Society of Dyers and Colourists (at the Royal Society, Burlington House, Piccadilly, London, W 1), at 6 p m —Mr D F Anstead "The Use of Colour in Cosmetics"

Society of Chemical Industry, Fine Chemicals Group (at 14 Belgrave Square, London, S W 1), at 6 30 p m —Dr B C L Weedon "Electrolytic Methods in Preparative Organic Chemistry"

Royal Institution (at 21 Albemarle Street, London, W 1), at 9 p m —Prof H Bondi, F R S "What Goes On Inside the Stars"

Saturday, November 7

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S E 23), at 3 30 p m —Mr B B Boycott "Devilfish—Octopuses, Squids and Cuttlefishes" *

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned

Director and an Assistant Director of the British Institute of History and Archæology in East Africa (Headquarters at Dar es Salaam and Kampala)—The Secretary, The British Academy, Burlington House, Piccadilly, London, W 1 (November 10)

Lecturer (preferably with special experience in the field of organic chemistry) in Chemistry at Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (New Zealand, November 15)

Imperial Chemical Industries Fellow (preferably under 29 years of age) at Durham or Newcastle for research in Engineering, Chemistry, Physics and allied subjects, including the biological application of chemistry—The Registrar, University Office, 46 North Bailey, Durham (November 16)

Plant Physiologist (honours graduate in science or agricultural science (or equivalent) with some years relevant postgraduate research experience) at the Irrigation Research Station, C S I R O , Griffith, New South Wales, Australia, to investigate effect of water stress in plants in new laboratories containing controlled environment chambers —Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W C 2, quoting Appointment No 500/115 (November 20)

Mullard Research Fellow (preferably with a Ph D degree or equivalent research experience) in Physics for research in various branches of solid-state physics, with particular reference to defects, semiconductor or surface properties—The Registrar, University College of North Staffordshire, Keele, Staffs (November 30)

Principal (with high academic qualifications, wide experience in administration, and conversant with developments in technological education)—The Clerk to the Governing Body, Battersea College of Technology, London, S W 11 (November 30)

Senior Lecturer in Physical Chemistry in the Department of Chemistry and Chemical Engineering—Prof F Sebba, Professor of Physical Chemistry, University of the Witwatersrand, Milner Park, Johannesburg, South Africa (November 30)

Lecturer in Theoretical Physics, and a Lecturer in Physics —The Registrar (Room 22, O R B) The University, Reading (December 7)

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Forestry Commission Bulletin No 31 Code of Sample Plot Procedure By Dr F C Hummel, G M L Locke, J N R Jeffers and J M Christie Pp v+113 (London H M Stationery Office, 1959) 15*s* net [138

Commonwealth Bureau of Helminthology Supplement to the Nematode Parasites of Plants Catalogued Under Their Hosts, 1955–1958 By Dr J Basil Goodey, Dr Mary T Franklin and David J Hooper Pp iii+66 (Farnham Royal Commonwealth Agricultural Bureaux, 1959) 7*s* 6*d* [138

Chelsea College of Science and Technology Prospectus, Session 1959–60 Pp 35 (London Chelsea College of Science and Technology, 1959) [188

Library Association Special Subject List No 30 Handicapped Children in Britain—Their Problems and Education Compiled by Mrs W A Axford (Books and Articles published in Great Britain from the 1944 Education Act to 1958) Pp 53 (London Library Association, 1959) 4*s* [188

Current Medical Research a reprint of the articles in the Report of the Medical Research Council for the year 1957–1958 Pp iii+46 (London H M Stationery Office, 1959) 3*s* 6*d* net [188

World Power Conference Annual Report, 1958 Pp 20 (London World Power Conference, 1959) [188

Ministry of Agriculture, Fisheries and Food Fishery Investigations, Series 2, Vol 22, No 7 The Spawning of the Plaice (*Pleuronectes platessa*) in the North Sea By A C Simpson Pp iii+111 (London H M Stationery Office, 1959) 37*s* 6*d* net [188

Report of Her Majesty's Civil Service Commissioners for the period 1st April, 1958 to 31st March, 1959 Pp 35 (London H M Stationery Office, 1959) 2*s* 6*d* net [109

Planning, Vol 25, No 435 (24 August 1959) The Work of Newspaper Trusts Pp 133–160 (London Political and Economic Planning, 1959) 3*s* 6*d* [109

Annual Report of the Yorkshire Philosophical Society for the year 1958 Pp 15 (York Yorkshire Philosophical Society, 1959) [109

Department of Scientific and Industrial Research Hydraulics Research 1958 The Report of the Hydraulics Research Board with the Report of the Director of Hydraulics Research Pp vi+74+8 plates (London H M Stationery Office, 1959) 5*s* 6*d* net [109

Ministry of Agriculture, Fisheries and Food Domestic Food Consumption and Expenditure, 1957 Annual Report of the National Food Survey Committee Pp vi+137 (London H M Stationery Office, 1959) 8*s* 6*d* net [109

Royal College of Science and Technology, Glasgow Prospectus of Full-time Courses for the One hundred and sixty-fourth Session, beginning 5th October, 1959 Pp 128 (Glasgow Royal College of Science and Technology, 1959) [109

Other Countries

Commonwealth of Australia Department of Supply Australian Defence Scientific Service Annual Report of the Defence Standards Laboratories for the year ended 30th June, 1958 Pp iv+56 (Maribyrnong, Vic Defence Standards Laboratories, 1959) [78

Indian Council of Agricultural Research Bulletin No 79 South Indian Cardamoms and Their Agricultural Value By P Abraham and G Thulasidas Pp vi+27 (Delhi Manager of Publications, 1958) Rs 3, 5*s* [78

Research Facilities of the United States Fishery Laboratory, Beaufort, North Carolina Pp 12 (Washington, D C Government Printing Office, 1959) [108

Metropolitan Life Insurance Company Statistical Bulletin Vol 40 (June 1959) Population Outlook for 1970 American Wives and Mothers Sex Difference in Cancer Mortality Decrease in Frequency of Drowning Pp 12 (New York Metropolitan Life Insurance Company, 1959) [108

United States Department of Agriculture Leaflet No 450 Horse Bots How to Control Them Pp 8 (Washington, D C Government Printing Office, 1959) 5 cents [108

Sudan Government Ministry of Agriculture Annual Report of the Research Division, 1953/54 Pp ii+235 (Khartoum Ministry of Agriculture, 1956) [108

Report of the King Institute of Preventive Medicine, Guindy, for the period from 1st April 1955 to March 31st 1956 By Dr S Govindarajan Report of the Government Analyst, Madras By Sri S Narayana Ayyar Pp 96 (Madras Controller of Stationery and Printing, 1959) [108

Commonwealth Scientific and Industrial Research Organization, Australia Division of Fisheries and Oceanography Technical Paper No 7 The Primary External Water Masses of the Tasman and Coral Seas By D J Rochford Pp 28 (Melbourne Commonwealth Scientific and Industrial Research Organization, 1959) [108

United States Department of the Interior Fish and Wildlife Service Research Report No 51 Fluctuations in the Commercial Fisheries of Saginaw Bay, 1885–1956 By Ralph Hile and Howard J Buettner Pp iv+38 25 cents Fishery Bulletin No 149 Grayling of Grebe Lake, Yellowstone National Park, Wyoming By Thomas E Kruse Pp iv+307–351 35 cents Fishery Bulletin No 151 Fluctuations on the Population of Yellow Perch, *Perca flavescenes* (Mitchill), in Saginaw Bay, Lake Huron By Salal El-Din El-Zarka Pp iv+365–415 40 cents Fishery Bulletin No 153 Life History of the Three-spine Stickleback *Gasterosteus aculeatus* Linneaus in Larluk Lake and Bare Lake, Kodiak Island, Alaska By John Greenbank and Philip R Nelson Pp iv+537–559 25 cents (Washington, D C Government Printing Office, 1959) [108

Northern Rhodesia Water Development and Irrigation Department Annual Report for the year 1958 Pp 7 (Lusaka Government Printer, 1959) 1*s* [108

Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture Comptes Rendus de Recherches, No 23 (Juillet, 1959) Travaux du Comité International des Recherches sur le Bas Fourneau Belgique—C E C A —France Pp 73 (Bruxelles Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture, 1959) 65 francs [108

British Territories in Borneo Geological Survey Department Memoir No 6 The Geology and Mineral Resources of the Jesselton Kinabalu Area, North Borneo By P Collenette Pp xviii+194+53 plates (Kuching Government Printer, 1958) 6 Malayan dollars [108

Annual Report of the National Museum, Bloemfontein, for the year ended 31st March, 1959 Pp 18 (Bloemfontein National Museum, 1959) [108

Commonwealth Scientific and Industrial Research Organization, Australia Division of Land Research and Regional Survey Katherine Research Station—Progress Report, 1946–56 Pp 60+5 plates (Melbourne Commonwealth Scientific and Industrial Research Organization, 1959) [108

Western Australia Report of the Government Chemical Laboratories for the year 1957 Pp 16 (Extract from the Report of the Department of Mines) (Perth Government Printer, 1959) [108

United States Department of Commerce Weather Bureau Technical Paper No 29 Rainfall Intensity-Frequency Regime Part 4 Northeastern United States Pp iv+35 (Washington, D C Government Printing Office, 1959) 1 25 dollars [108

Commonwealth Scientific and Industrial Research Organization, Australia Soil Publication No 14 Periodic Phenomena in Landscapes as a Basis for Soil Studies By B E Butler Pp 20 (Melbourne Commonwealth Scientific and Industrial Research Organization, 1959) [108

Bhulabhai Memorial Institute The Heritage of Indian Art Series No 1 The Gupta Temple at Deogarh By Madhuri Desai Pp 6+24 plates No 2 The Temple of Virattanesvara at Tiruttani By Douglas Barrett Pp 6+20 plates No 3 Hemavati By Douglas Barrett Pp 6+20 plates No 4 The Brahmapurisvara Temple at Pullamangai By James C Harle Pp ii+24 plates (Bombay Bhulabhai Memorial Institute, 1958 Distributed by N M Tripathi Private, Ltd Rs 10, 20*s*, 4 dollars, the set [108

Bulletin of the American Museum of Natural History Vol 118, Article 3 Oceanographic Observations in the Panama Bight, "Askoy" Expedition, 1941 By Warren S Wooster Pp 113–152 75 cents Vol 118, Article 4 Relationships Among the Living Squirrels of the Sciurinae By Joseph Curtis Moore Pp 153–206 1 dollar (New York American Museum of Natural History, 1959) [108

Deutscher Wetterdienst Deutsches Meteorologisches Jahrbuch, 1957 Pp xxxviii+228+5 karten (Offenbach a M Deutscher Wetterdienst, 1959) [138

Deutsche Akademie der Wissenschaften zu Berlin Veroffentlichungen des Geodatischen Instituts in Potsdam Nr 12 Zur Bestimmung der Geoidundulationen aus Freiluftanomallien Schwerewerte in Grossen Hohen uber der Erdoberflache Von Kurt Arnold Pp 68 17 50 D M Nr 13 Strenge Theorie der Absoluten Lotabweichungen als Funktionen der Freiluftanomalien der Schwere Von Kurt Arnold Pp 46 (Berlin Akademie-Verlag, 1959) [138

Basteria Tijdschrift van Nederlandse Malacologische Vereniging Vol 23 (Supplement) The Netherlands as an Environment for Molluscan Life Pp 176 (Amsterdam Nederlandse Malacologische Vereniging, 1959) [188

Annals of the New York Academy of Sciences, Vol 81, Article 1 The Cytopathology of Virus Infection By Robert Love and 36 other authors Pp 1–214 (New York New York Academy of Sciences, 1959) 4 50 dollars [188

F A O Picture Sheet No 9 Fishing Boats Pp 2 (Rome Food and Agriculture Organization of the United Nations, 1959) [188

United States Atomic Energy Commission Thyroid Radioiodine Uptake Measurement a Standard System for Universal Intercalibration (ORINS–19, Biology and Medicine) Pp ix+323 (Washington, D C Office of Technical Services, Department of Commerce, 1959) 3 50 dollars [188

Research Council of Alberta Geological Division Preliminary Report 59–1 Coal Reserves for Strip-Mining, Wabamun Lake District, Alberta By G Raymond Pearson Pp iv+55 (Edmonton, Alberta Research Council of Alberta, 1959) 50 cents [188

World Health Organization Notification of Communicable Diseases a Survey of Existing Legislation Pp 51 (Originally published in the *International Digest of Health Legislation*, 1958, 9, 605–653) 3*s* 6*d*, 0 70 dollars, 2 Swiss francs Technical Report Series, No 171 Mental Health Problems of Aging and the Aged—Sixth Report of the Expert Committee on Mental Health Pp 51 3*s* 6*d*, 0 60 dollars 2 Swiss francs (Geneva World Health Organization, London H M Stationery Office, 1959) [208

Canada Department of Mines and Technical Surveys Mines Branch Information Circular IC 105 The Story of the Early Days of the Extraction of Helium Gas from Natural Gas in Canada, 1915–1920 By John Satterly Pp v+42 (Ottawa Queen's Printer, 1959) 25 cents [208

New Zealand Forest Service Forest Research Institute Forestry Research Notes No 15 The Distribution of Stand Merchantable Volume by Log-Diameter Classes By W G Warren Pp 13 (Wellington Government Printer, 1959) [109

British Territories in Borneo Annual Report of the Geological Survey Department for 1958 By F W Roe Pp xii+247+50 plates (Kuching Geological Survey Department, British Territories in Borneo, 1959) 3 Malayan dollars [109

Osservatorio Astrofisico di Arcetri Annuario per il 1959 Pp 59 (Firenze Osservatorio Astrofisico di Arcetri, 1959) [109

Instituto de Fomento Algodonero, Bogota Boletin de Extension No 2 Cultivo del Algodon en Colombia By Ismael Collazos R Pp 52 Estudios Preliminares de Suelos Departamento del Magdalena y la Intendencia de la Guajira 1 Departamento del Magdalena By L Fernando Irusta e Emilio A Fortoul S Pp viii+97+2 maps 2 Intendencia de la Guajira By L Fernando Irusta e Emilio A Fortoul S Pp viii+71+21 plates–2 maps (Bogota Instituto de Fomento Algodonero, 1957) [109

Smithsonian Miscellaneous Collections, Vol 139, No 7 Early Tertiary Apheliscus and Phenacodaptes as Pantolestid Insectivores By C Lewis Gazin Pp 7+2 plates (Publication 4385) (Washington, D C Smithsonian Institution, 1959) [109

World Health Organization Technical Report Series No 175 Preventive Aspects in the Teaching of Pathology—Seventh Report of the Expert Committee on Professional and Technical Education of Medical Auxiliary Personnel Pp 30 1 Swiss franc, 1*s* 9*d*, 0 30 dollars No 176 Role of Hospitals in Ambulatory and Domiciliary Medical Care Second Report of the Expert Committee on Organization of Medical Care Pp 32 1 Swiss franc, 1*s* 9*d*, 0 30 dollars No 177 Social Psychiatry and Community Attitudes—Seventh Report of the Expert Committee on Mental Health Pp 40 1 Swiss franc, 1*s* 9*d*, 0 30 dollars No 182 Iron Deficiency Anaemia Report of a Study Group Pp 15 1 Swiss franc, 1*s* 9*d*, 0 30 dollars (Geneva World Health Organization, London H M Stationery Office, 1959) [109

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Telephone Number Whitehall 8831 Telegrams Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
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CONFERENCES: BIG OR SMALL?

MORE science means more information, in the form of books, journals and conferences No scientist needs to be reminded of this It was estimated recently that to keep up with all the current work a physiologist would have to read nearly four hundred papers a day, Sir George Thomson has even gone so far as to suggest that it is the impossibility of absorbing the necessary information that will ultimately halt scientific progress Communication is therefore a subject that we cannot afford to neglect The purposes of books and journals are, or should be, obvious, but the functions of conferences are more complicated

Scientific conferences grew as an answer to the problem of assimilating in a reasonable time the vast quantities of information scattered throughout the journals They do provide an answer—the meeting together of workers in similar fields and the collection of their ideas are the obvious advantages But is it the best answer? The basis of a conference is the presentation of papers, but why bother to read them? The distribution of all the papers to all the members would serve the same purpose It would even have advantages it is much easier to read a foreign language than to follow it by ear, and it is difficult to grasp a complicated argument at a single hearing In fact, something of the sort often happens when preprints are issued or when the proceedings are published in book form afterwards

The preprint was introduced to save time If all his audience are armed with his complete paper, there is no need for a speaker to give more than a summary This frees time for discussion or, more frequently, more papers. But the possibility of discussion is the great advantage of conferences Questions can be asked and suggestions made in print, but it is a very slow business and what takes months in the journals may take only minutes in the conference room Conferences have other advantages, of course Meeting other workers in one's own field is an obvious one But this is really an extension of the main advantage one meets in order to discuss

Conferences are getting bigger The Fourth International Congress of Biochemistry held in Vienna last September was attended by nearly five thousand scientists and the published proceedings run to fifteen volumes Two thousand one hundred papers were submitted at the Second Geneva Conference on the Peaceful Uses of Atomic Energy, and there are thirty-three volumes of proceedings These two examples are exceptions, but they do represent a real trend, at least in international conferences The question is whether this trend is a good thing Are bigger conferences necessarily better? In particular, are they better with regard to the advantages that conferences have over other methods of communication? The answer is, surely, no It has already been pointed out that the great asset of conferences is discussion, and the value of a discussion is usually inversely proportional to the size of the group There is such a press of papers that it is difficult to find time to read them, let alone discuss them Furthermore, most big conferences have to split up into sections which meet at the same time, and so it is impossible for an active member of a section to get any idea of the conference as a whole 'Interdisciplinary cross-fertilization', as it is unhappily called, does not take place

Fortunately, many people are aware of these points, in particular, some of the research foundations, such as the Ciba Foundation in Britain which recently celebrated its tenth anniversary, and the Josiah Macy Jr Foundation in the United States, deserve mention Both these organizations sponsor symposia Membership of a symposium is restricted to a small number of experts, so that profitable discussions are possible Afterwards, the complete proceedings are published It is a pity that there are so few institutions of this type interested in the physical sciences, most of them are biological, with a bias towards medicine

The Gordon Research Conferences, many of which are held every year in the United States, illustrate yet another approach They cover both the physical and biological sciences, and the membership of any one conference is restricted to a hundred They are "intended as a means of disseminating information which otherwise would not be realized through the normal channels of publication and scientific meetings" They differ from other conferences in that nothing is published, and no information may be disclosed without the speaker's consent At first this may seem odd in connexion with a conference "intended as a means of disseminating scientific information", but it enables those present to speculate freely without feeling that hundreds of critical readers will later censure them for making suggestions not backed up by adequate evidence Speculation is a vital part of science, so it is desirable that there should be some means whereby people can do so together, as well as alone A series of meetings of the Gordon type has recently been established in Britain The first Miller conference*, on radiation chemistry, was held at Portmeirion in North Wales during April 20–24 and was a success The conferences have been named after the late Dr N Miller, of the University of Edinburgh, who did much to help establish them

Big conferences are obviously here to stay. Many important aspects of them have not been discussed here, such as their significance as social events which promote international understanding, though it is to be hoped that the tendency to compete for national prestige, evident at some recent conferences, will not have the opposite effect Nevertheless, the small informal gathering, where ideas are exchanged as freely as facts, should not be neglected

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* Further information about the Miller conferences can be obtained from the chairman of the next meeting, which is to be held in 1961—Prof F S Dainton, School of Chemistry, The University, Leeds 2

HISTORY OF COSMOLOGY

Le Système du Monde

Histoire des Doctrines Cosmologiques de Platon à Copernic. Tome 10. Par Prof. Pierre Duhem. Pp. 528. (Paris: Hermann, 1959.) n.p.

THE great work of the late French historian of science, Pierre Duhem, on the history of cosmology from Plato to Copernicus, is now completed by the publication of Volumes 9 and 10. It will be remembered that only the first five volumes were published during the author's life in the years 1914–17. At the time there was no possibility of publishing the extant material for the remaining volumes, and it seemed that the historians of science would have to become resigned to the valuable work remaining a torso for ever. However, after the Second World War circumstances were ameliorated and so the rather rare situation could arise of the missing volumes appearing some forty years after the beginning of publication. On a previous occasion comment has been made upon the unavoidable drawback of the work becoming somewhat antiquated in the meantime. This, however, is only a slight disadvantage in comparison to the immense value to be attributed to Duhem's pioneering work, which forms the beginning of the modern interest in medieval natural science.

Of the new volumes, Volume 9 brings to completion the subject-matter of Volumes 7 and 8, mainly consisting of the Parisian physics of the fourteenth century. First, the theory of the tides is dealt with from William of Auvergne to Pierre d'Ailly; then follows the equilibrium of the Earth and the oceans, with an introduction to the idea of their centre of gravity of Greek and Arab commentators of Aristotle; the origins of geology, including the theory of the small movements of the Earth. Hereafter the important question of the rotation of the Earth is tackled, the discussion of which was inaugurated by Duhem in 1909 in his epoch-making article on Oresme as a precursor of Copernicus, in the *Revue Générale des Sciences*. This article is substantially reproduced here and is supplemented by a discussion of the views of that other great figure of medieval physics, Jean Buridan. The author repeats his former conclusion that the daily rotation of the Earth was duly discussed in the Parisian school of the fourteenth century and that in particular Oresme deserves credit for his anticipation of the ideas of Copernicus on the Earth's daily rotation. In the final chapter of Volume 9 the problems of the plurality of worlds in connexion with the possibility of the vacuum and with the variability of gravity with the distance to the centre of the world are discussed.

In Volume 10 it becomes quite clear that it is not offered to us as a complete work, but only as a compilation of fragments in greater or lesser degree of perfection. The title of the whole of Volume 10 was not chosen by Duhem himself but was added by the editors, who hoped to sum up by it the principal contents of the volume. It announces a treatment of fifteenth-century cosmology and of the schools and universities in which it was developed. The decline of the University of Paris in the first half of the fifteenth century is dealt with rather elaborately, but the treatment of the subsequent developments leaves something to be desired. The German universities of that century receive full attention, but the English and Italian ones remain somewhat in the background, although Paul of Venice (Paolo Nicoletti) has an extensive chapter devoted to him. This is also the case of Nicolaus of Cusa, the German cardinal, whose ideas are expounded at length. Finally, there are chapters on the Viennese astronomers Peurbach and Regiomontanus and on the fourteenth-century humanists Petrarca and L. Bruni, which, however, are far from dealing exhaustively with the relation of humanism to medieval philosophy.

The treatment is everywhere extremely clear and interesting; one regrets that the work was not completed by its author. E. J. DIJKSTERHUIS

RUSSIAN VIEW OF SPACE FLIGHT

Sputniks and After

By Karl Gilzin. Translated from the Russian by Pauline Rose. Pp. 285+25 photographs. (London: Macdonald and Co. (Publishers), Ltd., 1959.) 21s. net.

KARL GILZIN, a lecturer at the Moscow Aviation Institute, gives here a popular account of the past present and probable future of space flight. Brooding over the whole story is the spirit of Tsiolkovski, the 'father of astronautics', who foresaw in remarkable detail the techniques likely to prove most efficacious in space flight. Since British and American authors have scarcely done justice to this Russian pioneer, the eulogy in the present book will do no harm. It also serves to remind us how the Russians have created around the name of Tsiolkovski as patron saint, a mystique of space flight which is unparalleled in the Western world: it is no accident that experiments with animals, a necessary prelude to manned space travel, have figured so largely in the Soviet rocke and satellite programmes, or that *Sputnik* 1 was launched within a month of the centenary of Tsiolkovski's birth.

The subject-matter of the book can be divided into three sections, past, present and future. The first section expounds the principles of space flight and traces the development of rockets and other powe units in fair detail, though with a pro-Russian bias: Tsiolkovski figures in the history of the gas-turbine engine, but not Whittle. The second section, covering present developments, though it includes a good chapter on the atmosphere, is disappointing in detail: there is no new information on the Sputniks, and the meagre report of the results obtained from them (which appears to date from mid-1958) is, a little surprisingly, based largely on British radio observations reported in *Nature*. The last section is an excellent preview of space flight, which ends with an imaginary but realistic excursion to the Moon by a party of school-children.

The material is presented in an easy, expert manne and the book is well illustrated and technically reliable. There are a number of lapses and inconsistencies, however: for example, the rocket o *Sputnik* 1 is on p. 117 said to have completed its 900th circuit of the Earth on December 2, 1957 when it really came down on the previous day, as i implied on p. 131; on p. 139 Jodrell Bank is describe as an Irish radio observatory, a peccadillo startling t parochial ears; and the last paragraph on p. 10 does not follow from the one before.

The translation is competent, but too overloade with abstract nouns to be called graceful, and th phraseology sometimes conflicts with establishe usage: 'thrust' sometimes masquerades as 'traction' and 'solid fuel' as 'dry fuel'. D. G. KING-HELE

VAPOUR–LIQUID EQUILIBRIUM TREATISE

apour–Liquid Equilibrium
y Eduard Hala, Jiří Pick, Vojtěch Fried and takar Vilím Translated by G Standart (Czecho-ovak Academy of Sciences Monographs and Source aterial Chemical Section) Pp xviii+402 (London nd New York Pergamon Press, 1958) 90*s* net

THE authors have made an effort to produce a comprehensive treatise on all aspects of vapour–quid equilibrium, and certainly this is the most omplete work yet to appear on the subject It is ivided into three parts, covering respectively the hermodynamic basis for correlation of data, experi- ental techniques of measurement, and an up-to-date urvey of the relevant literature The theoretical asis of the subject is developed in four chapters, arting with general thermodynamic relations in the st chapter, introducing the concept of ideal solutions the second, and finally dealing with real solutions the third and fourth

Although the content of Chapter 1 may be found in ny text-book on thermodynamics, and will be con-dered elementary by most readers, it is useful to ave such a summary of the relations to hand, and it lso serves to introduce the symbols and nomen-ature—we learn, for example, that the Gibbs free ergy is to be referred to as the "free enthalpy". is a pity that the chapter should be marred by the mmon student's error made in passing from expres-ons involving "number of moles" to those involving ole fraction" In spite of the warning at the foot page 10, the authors themselves fall into the trap n page 11 in obtaining equation I–47 The same ror is made later in the first expression of equation -255 on page 70, while equation I–257 on the same ge is not deducible from equation I–148, but ther follows directly from equation I–147 In a milar way, equation I–141 on page 28 is in fact rrect, and is not obtained, as stated, from the roneous equation I–47 In all these cases, con-sion would be avoided if the complete set of variables volved were given for each equation, rather than nply indicating the constancy of pressure and mperature In Chapter 2, the properties of ideal lutions are adequately dealt with, and Chapter 3 troduces the concepts of activity and activity co-icient, and develops the relevant thermodynamic lations The major part of Chapter 4 is concerned th integrations of the Gibbs–Duhem equation, and is is probably the most valuable section of the ole book The treatment is systematized in the y first presented by Wohl, and forms an excellent mmary of the many empirical relations now isting, including those due to Van Laar, Margules, atchard and Hamer, and Redlich and Kister It is pity that Wohl's own contribution is represented ly by his earlier work, and that no mention is ade of his 1953 paper The value of this section is hanced by the inclusion of many worked numerical amples of the application of these equations, to-ther with comparisons of the results with direct perimental data, as well as a summarized presenta-on of all the relations in tabular form Thus, hough the authors have wisely refrained from tempting a general assessment of the relative lues of these relations, they have made it easy r the reader to make his own comparisons for any ecific case

The authors show good practical sense in following up this survey with a discussion of methods for deriving complete equilibrium data from indirect measurements, again fully supported by numerical examples Here one could perhaps wish for a little more discussion on the relative suitability of the methods for numerical solution of these particular differential equations, since two methods have been introduced somewhat arbitrarily in the examples. Some discussion of the magnitude of the errors involved in the different methods would also be welcome On reading this chapter, one is left with the impression that, since the Gibbs–Duhem equation is obeyed, all the correlations are at least thermodynamically consistent The limitation of the Gibbs–Duhem equation, as an expression of variation with composition of a single phase at constant pressure and temperature, is explicitly stated in the earlier chapters However, as is frequently done, it is later assumed in some applications to hold along the equilibrium line, which for binary mixtures must involve variation of either temperature or pressure It is only fair to the authors to say that in each case this assumption is noted, but its significance and the approximation involved are rarely sufficiently stressed, and are more often glossed over, as in the case of the derivation of the expressions for limiting relative volatilities on page 45

In view of the detailed treatment accorded to these integrations of the Gibbs–Duhem equation, it is disappointing to find only a cursory treatment of alternative methods of correlating equilibrium data. The effect of non-ideality of the vapour phase is disposed of in less than eight pages, which also contain the only reference to equilibrium-ratios, or K-values Surely the Benedict equation, and all that arises from it, is worth more than a passing reference ? The law of corresponding states is illustrated by two numerical examples, but the treatment is wholly inadequate The reader will find no mention of the 'convergence-pressure' concept, nor indeed is any indication given of the difficulties arising in correlating equilibrium data when the temperature is above the critical temperature of one or more of the components Here the absence of vapour pressure makes impossible the application of the Gibbs–Duhem integrations, or even the ideal solution laws

Part 2 is concerned with laboratory techniques, and should be considered as a review of a wide range of techniques, rather than as a detailed discussion and assessment of the different methods The five chapters cover criteria of purity, temperature and pressure measurement, vapour pressure and vapour–liquid equilibrium determinations In each case a good variety of techniques is presented, and, although there is seldom an adequate assessment of precision and the treatment is sometimes superficial—for example, the dead-weight piston pressure-balance is dealt with in six lines—there are usually sufficient references to the literature to enable one to obtain all the information required

The authors state in their preface that they have deliberately avoided description of current laboratory equipment, and on these grounds have excluded thermostats This does not seem logical for a book which includes chapters on measurement of temperature and pressure and discusses manostats in some detail One cannot deny the usefulness of these in directing attention to points which so many workers overlook, and in view of the authoritative treatment of methods of determination of vapour pressure and equilibrium compositions one feels that the authors would have much to contribute on the special problems connected with thermostats Many readers will be grateful for the extensive review of equilibrium stills, particularly because of the systematic method of classification employed, and the summarized comparison of them in a single table at the end of the chapter

Part 3 consists of an alphabetical index to more than 1,200 references to original work on the experimental determination of equilibrium data This impressive list is all the more valuable as it gives world-wide coverage of technical publications up to February 1957

Although the book falls short of a comprehensive treatise and in its present edition has a number of shortcomings, it is nevertheless an outstanding contribution to the subject, and contains so much of solid worth that most workers in the field should learn something from its pages, and find it of constant value as a reference work R SARGENT

TRANSISTOR ELECTRONICS

Junction Transistor Electronics

By Richard B Hurley Pp xvii+473 (New York John Wiley and Sons, Inc , London Chapman and Hall, Ltd , 1958) 100*s* net

Transistor Electronics

By Arthur W Lo, Richard O Endres, Jakob Zawels, Fred D Waldhauer and Chung-Chih Cheng Pp xii+521 (London Macmillan and Co , Ltd , 1958) 45*s* net

ON its own Hurley's book has a certain amount to commend it is, however, difficult to understand the publishing policy of Messrs John Wiley and Sons About a year ago they published an excellent work on junction transistors edited by R F Shea, a book which received very favourable reviews Hurley covers much the same ground as Shea, differing only in detail, and although I must admit his book is possibly designed more for use as a text-book, it cannot help being a competitor to Shea's work

Introductory chapters on semi-conductor principles lead on to the small signal equivalent circuit of the transistor and the use of this circuit in the analysis of the transistor audio-amplifier A chapter is devoted to bias stabilization and another to the application of negative feedback The subject-matter of Chapter 6, "The Nature of Internal Noise Generation and Its Outward Effects", receives much better treatment than in Shea's book where it was dismissed, rather perfunctorily, in about a page

The performance of a transistor under large signal conditions is considered and this leads to the problems of the design of power amplifiers Direct-current amplifiers, video amplifiers, tuned amplifiers, automatic gain control, sinusoidal oscillators, modulation circuits all receive attention by way of separate chapters Three more chapters deal with transistors in switching applications and in their use as relaxation oscillators

Two rather special applications of the transistor, namely, in regulated power-supplies and saturable reactor-circuits, have individual chapters and receive a more detailed treatment than in Shea's work

As a book for reference it suffers from the absen of a list of symbols, and what is more serious, althoug the author himself admits it, is the use of the san symbol with entirely different, and different shad of, meaning

The presentation and reproduction is, of cours up to John Wiley's usual high standard

The work on "Transistor Electronics" by I *et al* is a reprint of a well-known book published 1955 in the United States by Prentice-Hall It h now been published in Britain by Macmillan, but t printing was carried out (and very well, too) in t Netherlands So far as I can see there are no alter tions to the original text It covers substantially t same ground as Hurley's book but of course Hurl has three extra years development to include, a in a field that is subject to continual metamorpho this gives him a considerable advantage

The authors, who were all with the Radio Corpor tion of America when the book was written, favo the four-terminal network approach to the transist equivalent circuit and deduce the performance the various circuits using this as the basis A ve useful table shows the many varied forms the fou terminal equivalent network can take and will very useful for reference The book is intended bo as a text-book for students of this subject and as reference work, but I feel that it is in the form application that it will be most useful

J W R GRIFFITHS

PROGRESS IN PHYSIOLOGY

Annual Review of Physiology

Vol 21 Edited by Victor E Hall, in associati with Frederick A Fuhrman and Arthur C Gies Pp viii+636 (Palo Alto, Calif · Annual Review Inc , and the American Physiological Society, 195 On sale by Annual Reviews, Inc) 7 dollars

WITH the publication of Vol 21, the "Annu Review of Physiology" comes of age, though it still a mere fledgling to its 28-year sister publicatio the "Annual Review of Biochemistry". Its grow over the years might be considered unphysiologic for its size at birth (705 pages) was greater than is now (636 pages) The editorial committees ha prevented the volume from becoming unmanageab large, but the question they raised last year remai unanswered whether the present policy of "ski ming one volumeful of physiological cream" can continued indefinitely With the growing output research, it means that a progressively smaller pr portion of the total published work is reviewed ye by year A similar problem exists for annual revie in other subjects Those who write the reviews a faced with the difficulty of selection If they inclu too many papers in their survey, they tend to produ little more than an annotated card index, useful f reference but almost impossible to read through they select some of the more important recent wo in their subject and give themselves room to discu it, they produce a more interesting and stimulati review but may leave out a good deal of significa research On the whole, the present reviewers ha managed to make their summaries interesting read and useful for reference

The prefatory chapter is by A V Hill and de with the heat production in muscle and nerve fro

348 (when Helmholtz made the first attempts at ıeasurement) to the outbreak of the First World 'ar The chapter is preceded by a portrait of its ıthor at work, complete with umbrella installed as a otection against floods from the laboratory above ' rof Hill discusses some of the earlier work in the ght of present-day knowledge and he includes miniscences of research at Cambridge and of some the people there and elsewhere who influenced him is good to know that this chapter will be the eginning of a future monograph

This year's volume contains the usual chapters ı the basic subjects, heart, peripheral circulation, spiration, digestion, kidney, water and electrolyte etabolism, the nervous system (four reviews) and production There are chapters on blood clotting, ne, transport through membranes, heat and cold, ıd chemical influences on cell division and development Endocrinology this time covers the adeno-pophysis and adrenal cortex, and the pancreas ısulin and glucagon)

The chapter on Russian physiology deals with etabolism and endocrinology This is the last time ıat Soviet research will be treated separately In ture, reviewers will be encouraged to make use of ıe translations of Russian papers which are becoming creasingly available, and to discuss these papers ong with the work from other countries The final ıapter, on comparative physiology, reviews work on e annual reproductive cycles of marine inverte-ates

The editorial committee pays its usual tribute to e authors (who write from six different countries) r undertaking the heavy task of preparing these ırveys, all physiologists will wish to associate emselves with this tribute, and will wish the Annual Review of Physiology" many further years useful life

D C HARRISON

RUMINATION

etabolism in the Rumen

y E F Annison and D Lewis (Methuen's Mono-aphs on Biological Subjects) Pp 184 (London ethuen and Co, Ltd, New York John Wiley d Sons, Inc, 1959) 15*s* net

HIS is an interesting, well-written and up-to-date account of the microbiology of digestion in e rumen and the resultant biochemical pathways metabolism In the rumen complex interactions ke place which account for the importance of the minant in agriculture Mammals do not secrete llulases in their digestive juices, and the degradation dietary cellulose in the rumen, its major function, achieved by the cellulolytic activities of the micro-al population This releases potential substrates om refractory plant materials and permits the rmation of metabolic end products in the rumen ıich are afterwards the main source of energy for e animal This enables ruminants to live on coarse rous foods which would otherwise not be available . other herbivora, such as the horse, there is a nilar but more limited dependence on the activities the micro-organisms of the cæcum

The production of certain essential amino-acids and tamins and the conversion of some dietary con-tituents into microbial substance are other metabolic ansformations Symbiotic relationships of a remarkable degree have thus been developed in the rumen The separate metabolic pathways can seldom be adequately examined or controlled in isolation The microbiol activities are delicately poised between catabolic and anabolic processes Thus, for example, in protein metabolism the microbial contributions may range from a rapid breakdown of excess ingested protein to ammonia and volatile fatty acids, to the extreme synthetic phase whereby urea from the circulating blood may diffuse into the rumen and be used for the growth of cellulose fermenting bacteria The techniques now becoming available to the biochemist, physiologist and microbiologist are enhancing their ability to study rumen function, one of the most fascinating and rewarding fields for their attention

It is hoped that this book will help to dispel the considerable ignorance of many biochemists, physiologists and bacteriologists concerning what happens in the ruminant The study of such animals should have its place in the normal curriculum of these subjects While some of the pioneer work was set in motion by Tappeiner in Germany and by Schalk and Amadon in North Dakota, workers in the United Kingdom have made remarkable advances in this fascinating field, and the names of Baker, Barcroft, Phillipson, Elsden, Pearson, Smith, Oxford, McDonald, Synge and Chalmers are to be listed among the pioneers But Marston in Australia, Hungate, Bryant, Doetsch, Gall and Huhtanen in the United States, Balch, Blaxter and Hobson in Great Britain have, among many others, made their mark The authors, too, have justified their position to be knowledgeable authorities in this field

D P CUTHBERTSON

DEVELOPMENTAL BIOLOGY

The Developmental Biology Conference Series, 1956

Cytodifferentiation Edited by Dorothea Rudnick. Pp xi+148 28*s* net Environmental Influences on Prenatal Development. Edited by Beatrice Mintz Pp xiii+87 22*s* 6*d*. net Regeneration in Vertebrates Edited by Charles S Thornton Pp xi+108 52*s* 6*d* net Embryonic Nutrition Edited by Dorothea Rudnick Pp xi+113 24*s* net Immunology and Development Edited by M V Edds, Jr Pp xi+59 19*s* net Dynamics of Proliferating Tissues. Edited by Dorothy Price Pp xv+96 24*s* net Wound Healing and Tissue Repair Edited by W. Bradford Patterson Pp xi+83 21*s* net (The Developmental Biology Conference Series, 1956, held under the auspices of the National Academy of Sciences—National Research Council) (Chicago · University of Chicago Press, London Cambridge University Press, 1959)

A LIVING organism has a present and two pasts, one evolutionary and the other ontogenetic A study of any one of the three is ultimately comprehensive and will embrace the other two; any knowledge of one must be relevant to the others, and yet to each there is a distinctive biological approach

The developmental biology conference series, a marathon of discussion meetings held in the United States with international participation in 1956, can be said to mark the end of a period during which the developmental approach to biology has been establishing its aims and staking its frontiers Embryology, in the strict sense, is no longer granted automatic precedence, nor is morphogenesis the key problem Events in any part of the ontogenetic cycle are seen in terms of the contribution they can make to an understanding of the whole

These meetings were thus. if anything, even less restricted in scope than might be suggested by the titles of the volumes in which they are reported Though there is remarkably little repetition of one in another, between them they touch upon a substantial fraction of all experimental biology However, it was not intended that the series should be comprehensive and there are, inevitably, many gaps, some premeditated and others contingent upon the informal nature of the discussions This is not a fault, but it does mean that some of the reports will be of most value to those already familiar with the background to the themes discussed This is true, for example, of "Cytodifferentiation" and of "Environmental Influences on Prenatal Development", both of which contain stimulating presentations of recently discovered facts and recently developed ideas On the other hand, the more formal reviews in "Regeneration in Vertebrates" provide excellent and comprehensive surveys of a few selected experimental situations

These seven volumes do indeed vary greatly in character, partly because the meetings themselves took different forms and partly by editorial decision At the one extreme (for example, in "Embryonic Nutrition") we are offered an orthodox sequence of papers and discussions of them, with a complete list of the authorities referred to At the other (in "Immunology and Development") the identities of discussion leaders, participants, and absent authorities are not defined and their work is merged into a sort of collective stream-of-consciousness report Both volumes are successful, but their usefulness is clearly of different kinds

Formal considerations apart, it must be confessed that the series, viewed as a whole, lacks the intellectual coherence that the "unity of subject matter" claimed for it by its organizer, Paul Weiss, might lead one to expect We have not yet a continuous spectrum of problems in developmental biology But these meetings certainly reflected real progress towards a consciously unified approach to developmental processes, a progress that will be further stimulated by the publication of their proceedings.

D R Newth

THE HETEROGENEITY OF HUMAN HÆMOGLOBIN

Abnormal Hæmoglobins

A Symposium Organized by the Council for International Organizations of Medical Sciences Edited by J. H P Jonxis and J F Delafresnaye Pp ix+427. (Oxford· Blackwell Scientific Publications, Springfield, Ill Charles C Thomas, 1959) 45s net

THIS volume contains the papers and discussions of a symposium on abnormal hæmoglobins held in Istanbul in September 1957. Since Pauling's demonstration in 1949 of an electrophoretically distinct hæmoglobin in sickle-cell anæmia, the discovery of new variants has proceeded with increasin momentum so that, at present, 15 hæmoglobins hav been designated by letters of the alphabet Four sub fractions of normal adult human hæmoglobins, A_1 A_2, A_3, A_4 (A_2'), and one normal fœtal hæmoglobi are now known The complexity of the situatio is illustrated by reports of a further seven variant which are given provisional names derived from th place of discovery, in order to avoid confusion of th nomenclature

The interest in abnormal hæmoglobins is spreadin throughout the world, and involves many scientifi disciplines It is this widespread multidisciplinar interest which has brought the subject within th ambit of the Council for International Organization of Medical Sciences Participants in the symposiu included eminent workers of international repute, an others who have become recognized for their work i their own geographical localities The papers hav been grouped under two main headings "Biologica Considerations" and the "Geography of Hæmoglobins" Itano (United States) opens the symposiu with an introductory discourse on the "Genetic an Physical Factors in the Heterogeneity of Hæmoglobin" The identification of human hæmoglobin is described by Huisman (Holland), though practica details of technique are not given This paper i supplemented by Cabannes and Portier (Algiers with a description of their electrophoretic experience of the newly discovered hæmoglobins Two group of workers using two different techniques bring fort evidence that the alkali-resistant hæmoglobin o thalassæmia is not fœtal hæmoglobin a view no held by the majority of authorities Derrien (France bases his evidence on solubility experiments, whi Dianoco and Castay (Tunis) describe immunologica differences using a complement fixation test for th detection of hæmoglobin antibodies Clinical an hæmatological aspects of the various hæmoglob syndromes are described by Zuelzer (United States Chapters on fœtal and sickle cell hæmoglobin ar provided by Jonxis (Holland) and Vandepitte (Belgia Congo) respectively Fessas (Greece) described th alterations of the hæmoglobin pattern in thalassæmi The first section is concluded by chapters on th genetic aspects by Neel (United States) and o the hæmoglobin types of animals by Huisma (Holland) and his colleagues

In the part on geography, the following autho have dealt with the position of abnormal hæmoglobins in their region Aksoy (Turkey), Pouy (Iran), Silvestroni and Bianco (Italy), Fessas (Greece Vandepitte (Belgian Congo), Portier, Cabannes an Duzer (Algiers), Edington (Ghana), Chatterjea (India de Silva, Jonxis and Wickramasinghe (Ceylon), Na Nakorn (Thailand), and Lie-Injo Luan Eng (Indonesia Prof Jonxis contributes some interesting compariso of the frequencies of the sickle-cell and hæmoglob C traits in the Dutch colonies of Curacao and Surina Two chapters by Lehmann (United Kingdom) pu the subject of hæmoglobin variants in their prope geographical perspective

The nomenclature of the newer hæmoglob variants H–N is given in an appendix, togethe with the studies required before a new hæmoglob can be designated

This volume will provide a useful account of th abnormal hæmoglobin situation up to early 195 whether the reader be a hæmatologist, physicia biochemist, geneticist or anthropologist

J A M Ager

A Handbook of Lattice Spacings and Structures of Metals and Alloys

By Dr. W. B. Pearson. (International Series of Monographs on Metal Physics and Physical Metallurgy, Vol. 4.) Pp. x+1044. (London and New York: Pergamon Press, 1958.) 262*s*. 6*d*.

THIS is a formidable work of more than 1,000 pages. It is divided into two parts. The first part is an account of the methods used in the accurate determination of lattice spacings and crystal structures, and of the significance of the results in connexion with the location of phase boundaries, the application of electron theory to metals and alloys, and the effect of magnetic properties on lattice spacings. A brief mention is also made of the role of lattice parameter measurements in miscellaneous fields such as thermal expansion and superconductivity.

The second part occupies most of the book, and consists of a collection of crystallographic data. This includes the lattice spacings and crystal structures of the elements, of binary, ternary and quaternary alloys, and of borides, hydrides, carbides, nitrides and oxides. The largest section in this part is an alphabetical index of the work on metals and alloys. For each alloy system a brief description of the equilibrium diagram is given, together with a critical assessment of the various lattice parameters obtained by different workers. Sufficient practical information on the methods of obtaining the data is given to make it unnecessary in most cases to refer to the original papers. References are included up to 1957.

The labour involved in producing this work must have been considerable, and the author is to be congratulated on the result. It will prove to be of great value to the research worker, and should be in the library of all people who are interested in the physics of metals. The book is unfortunately very expensive.

J. A. CATTERALL

The Birds of Sydney (County of Cumberland), New South Wales

By K. A. Hindwood and A. R. McGill. Pp. iii+128+19 plates. (Sydney: Royal Zoological Society of New South Wales, 1958.) 12*s*. 6*d*.

THE Sydney Basin is essentially Triassic in origin and was formed by successive lake deposits overlying coal measures of Permian age. Above the coal is red shale, and above this there lies a tough sandstone surmounted by a final capping of grey shale. Here and there erosion has bared the underlying structures; in fact, the city of Sydney is built on and partly of Hawkesbury sandstone. Each geological type supports its own characteristic flora and, correspondingly, fauna. The red shale of the deep valleys has attracted an Indo-Malayan vegetation, as well as a fauna partly of northern affinity. The flowering heaths of the sandstone support many honey-eating animals and others; and in the open forests of the surviving top-shale is found a fauna which is often closer allied to that of the dry interior than to the animals in the cool valleys nearby.

Messrs. Hindwood and McGill have compiled a useful list of the 377 species of birds—both land and marine—native to this zoologically fascinating region. Under each name are five or six lines, mentioning salient points of description and the localities in which each species can be found. The compilation, therefore, remains of strictly local interest; and this is a pity. The area abounds with problems relating to the wider aspects of avian zoogeography, ecology and dispersal and it is regrettable that no attempt has been made to get to grips with such matters. The book is illustrated with a map of the area and excellent photographs of about thirty species.

A. J. MARSHALL

Food for Survival after a Disaster

By Dr. R. C. Hutchinson. Pp. ix+90+6 plates. (Carlton, N.3: Melbourne University Press; London: Cambridge University Press, 1959.) 13*s*. 6*d*.

THE disaster envisaged in the title is that of shipwreck, forced plane landing, or vehicle breakdown in a desert area, rather than the large-scale disaster of modern war, and the information given is primarily that which would be of the greatest value to individuals or small groups of survivors trying to keep alive under adverse conditions in strange surroundings. In addition to this, however, the book also contains much pertinent detail on de-salting kits and on the selection and packaging of survival rations which would be of great use to those planning scientific expeditions and to commercial shipping and air-line companies who may not have access to pamphlets prepared for the Armed Forces.

The author claims to speak from personal experience as "a survivor on both land and sea", and has certainly condensed a wealth of material into a very small space and presented it in a most readable form. The chapter on "Possible Supplementary Sources of Food" is a whole lesson in ecology in itself and one that should stimulate the interest of any school-boy. Decidedly a book to be recommended to all inveterate travellers: the day might well come when they would owe their lives to what they had learnt from its pages.

M. W. GRANT

From Microphone to Ear

Modern Sound-Recording and Reproduction Technique. By G. Slot. Second, revised and enlarged edition. Pp. ix+258. (Eindhoven: Philips' Technical Library; London: Cleaver-Hume Press, Ltd., 1959.) 21*s*.

THIS book might well be entitled "Gramophones, from *A* to *Z*", for it seems to contain everything, even (p. 82) how to remove gin spots from your records! It is obviously written by an enthusiast for enthusiasts, and its quality has been well preserved in the excellent translation. Many an amateur constructor, 'hi-fi' or stereophony fan, or even the intelligent listener with a curiosity to learn more of what gets the music on to the records and out of the loudspeaker, will find plenty of reading here. Recording techniques, studio work, tracking theory, loudspeaker dynamics, cabinet design, motor construction, care of records, negative feedback, tape recorders, sound effects, automatic record changers, needles, hum—the lot.

With this enormous coverage the treatment of much of the material will seem shallow to professionals and it would be easy to be critical, but purposeless. The book is informative, practical, well written and illustrated by many simple line diagrams and photographs. It makes a welcome and timely appearance, in these days of such increased demand for better musical recording and reproduction. Many enthusiasts want to assess the merits of this technique and that, or to judge the quality of their equipment, or to improve it; this book will help them.

COLIN CHERRY

ELECTRONIC PREDICTION OF SWARMING IN BEES

By E F WOODS*

THE honey bee is one of man's two domesticated insects (the other being the silkworm), and has been cultivated before the dawn of history, principally for the production of honey The primitive method of beekeeping revolved around the instinct of bees to swarm Each colony produced by swarming 6–15 new colonies, usually in spring, and those colonies were hived and allowed to build up in the summer, gathering and storing honey In the autumn, all but one of the colonies resulting from one mother colony were destroyed, and the honey and wax harvested The remaining colony repeated the cycle next year This system is still in use in some countries, such as Abyssinia, Palestine, and India, but is rapidly falling into disuse.

In 1851, Langstroth, in the United States of America, introduced the movable-frame hive and found that, if swarming could be prevented, the quantity and quality of the honey were enormously improved But the difficulty lay in preventing swarming, the bees' natural method of reproduction, and for a century the only method known has been meticulously to examine all colonies at regular intervals, and take appropriate action with those showing visible signs of an impending swarm, namely, queen cells This examination is made on each colony every 9 or 10 days from about mid-April to mid-July—about eight operations in a season—and takes 5–10 min for a skilled operator, who must be physically robust, since he has to lift the components of a hive weighing up to 60 lb each The repeated disturbance to the bees seriously reduces the honey crop Moreover, since only about 3 per cent of the colonies show signs of swarming, 97 per cent of this work is wasted When it is realized that this system is applied to more than 10,000,000 colonies of bees throughout the world—more than 5,000,000 in the United States alone—the tremendous waste of labour and honey becomes obvious This system is costly in labour (about £3 per colony per annum), and the loss of honey due to disturbance is also considerable, quite comparable in value with the actual outlay in labour

My work on the analysis of the sounds of activity in the hive indicated that small variants of the normal sound could be identified which were indicative of abnormality Certain characteristic sounds in particular were found to be adequate criteria for, among other possibilities, the prediction of swarming A technique was therefore developed, and an instrument designed and produced for monitoring the condition and behaviour of a colony with no disturbance to the bees whatsoever

An analysis of the sound spectrum of a large healthy colony of bees, in three conditions, is given in Fig 1, curves I, II and III. These curves were obtained by two methods by selecting the wanted sound by means of a filter circuit and relating it by ear to a similar pure tone, attenuated , and by the use of a standard wave-analyser The two methods gave similar results, and the second was adopted, being much simpler and quicker As no absolute standard is available, all sounds were related to the loudest, the flight noise

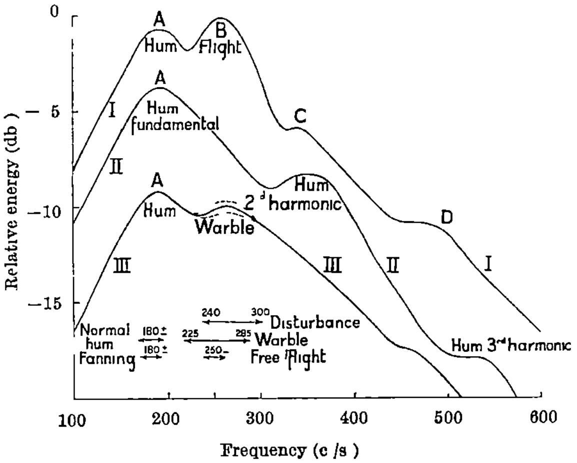

Fig 1 *Apis mellifica*, same colony July 7–8, 1959
I, 2 p m , harvesting , II, 2 a m , no flight , III, deprived of fliers and dequeened

Fig 1, curve I, represents the normal day-time spectrum *A* is the basic sound produced by the action of the spiracular valves on the inspired and expired air, varying for an individual bee in synchronism with the breathing movements, but amounting *en masse* to a steady hum at 180 ± 5 c /s *B* shows the flight sound, with a frequency of 250 ± 1 c /s *C* and *D* are harmonics of *A* and *B*, merging at high frequencies There is no supersonic component

Fig 1, curve II, refers to the same colony after dark The general sound is weaker, and the flight component is missing Curve III is from the same colony, deprived of fliers, and with the queen removed, the recording having been taken 3 hr after her removal The important component at 225–285 c /s will be noted, varying somewhat in frequency, but not more than ± 3 db in volume, which has built up steadily to a maximum It is almost a true warble technically so defined

This warble is a consequence of the removal of the queen, and the time at which it appears varies with several factors (*a*) the smaller the colony the shorter the time and vice versa , (*b*) the busier the colony, the longer it takes to appear , (*c*) the presence of numerous nurses at certain times of the year shortens the period , (*d*) the period varies with different breeds of bee, the more 'phlegmatic' dark bees tending to have slower reactions

The warble not only increases in volume, building up relatively steadily to a peak, but its nature also changes For a typical time of 5 hr from removal of the queen to maximum sound, the process would be as follows.

0–10 *min* A faint, steady rise and fall in the frequency-range 225–285 c /s , made by the nurse bees immediately attendant on the queen, probably those obtaining queen substance from her

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10 min–3 hr. A bubbly, jerky sound, in the same frequency-range, somewhat plaintive The bees act as if distressed, and are very subdued in behaviour

3–5 hr The warble, still in the range quoted becomes more jerky and fierce The bees become irritable

5 hr The sound becomes a twanging sound, and at this point the bees tend to become intractable and fierce Queen cells appear

After 5 hr The warble disappears in a few minutes and is replaced by the 'roar', a sound of frequency 180 ± 2 c /s , varying in volume by ± 20 db The bees are now usually intractable and vicious

At any time during the warbling, the queen can be replaced with little risk of loss, and at the peak, her acceptance by the colony is almost certain After the cessation of the warble, introduction of a queen is almost impossible

A large number of experiments over several years showed that the warble was produced by nurse bees. aged 4½–6 days, and that it could be related very accurately to their inability to dispose of the royal jelly, automatically produced at this age This general explanation covered every observation of the occurrence of the warble at any season and in all conditions

Partial slowing down of oviposition occurs during the 'fining down' of the queen in the pre-swarm period, giving rise to a progressively increasing warble as more and more nurse bees are thrown out of work, but it has not hitherto been noticed, because not only is it very weak, but also the fliers which comprise the swarm, no longer stimulated to fly for harvest, remain in the colony and increase the normal sound.

It therefore appeared that an increasing warble should be detectable from the start of swarm-preparation, and that a means of detecting it might afford a means of predicting the onset of swarming

It will, however, be obvious from the curves that this sound, at its very loudest, and with fliers removed, is 10 db below the general noise-level, and is never clearly audible to the unaided ear until the swarm has left the hive

A filter amplifier circuit was therefore constructed, reducing all frequencies outside the range 255 ± 30 c /s , and providing considerable amplification to the residue, and it was found that the warble was distinguishable as much as 25 days before the issue of the swarm, and clear and unmistakable about 15 days before swarming Thus with a suitable nstrument, the onset of swarming can be predicted a week or more before the visible signs—namely, queen cells—are laid down, and a fortnight before the issue of the swarm

A complication arises in that many, probably most, colonies supersede a failing queen at least once, the daughter mating and ovipositing before the mother is destroyed (by the bees) There is thus only a small decrease in egg production, but the progressive failure of the old queen, reducing the supply of queen substance, has an effect similar to egg reduction, and the nurses warble, a sound weaker but in no way different from the pre-swarm warble It is, however, quite easy to determine which process is in prospect If a colony be disturbed, it produces a characteristic hiss, and if the colony is in breeding-balance, that is to say, the eggs and young larva are fairly well equated to the nursing potential, this is a short vicious sound, lasting only tenths of a second before ceasing To get this 'shape' of sound, the stimulus must be short and apply to all bees a jerk on the hive suffices If the number of eggs is falling relatively to the nursing potential, the sound has the same character, but is reduced in peak volume and lengthened in time With a little practice it is easy to distinguish an incipient swarm from supersedure

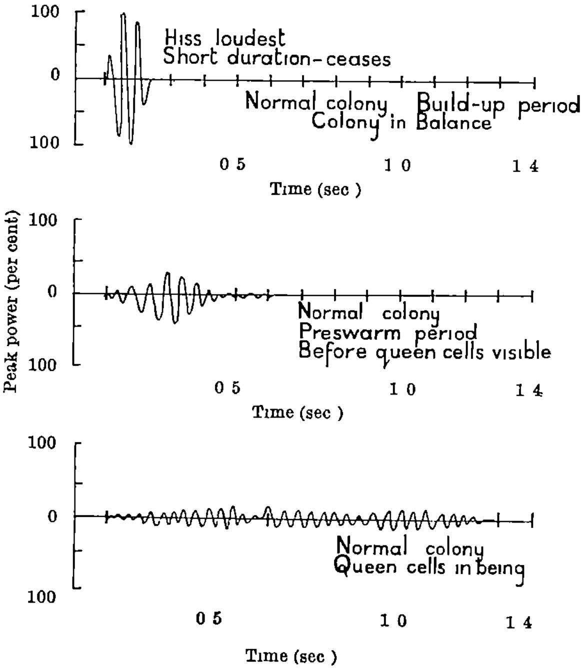

Fig 2 Hiss (diagrammatic) In the queen cell-in-being diagram (bottom) the duration grows to 10 sec or more and the power vanishes to zero

To permit the reliable assessment of the hiss—a random spectrum of sound from about 3,000 c /s upwards—a second filter was constructed The hiss was then amplified and presented to the ear in unmistakable volume Fig 2 illustrates the hiss cycle It should be noted that Fig 1 represents actual measurements on a typical colony, whereas Fig 2 is diagrammatic

Fig 3 shows the progress of a pre-swarm cycle The build up of warble can be regarded as typical, but it should be understood that it varies both in frequency, that is, it warbles, and also from instant to instant in volume The frequency excursion is now quite definite, from 225 to 285 c /s , but the instantaneous variation in volume seems to be unpredictable However, the average volume rises steadily as shown (Fig 3)

The practical utilization of these sounds requires an instrument which not only selects and amplifies them, but is also simple to operate, robust, cheap and weatherproof It must also be battery driven The recent development of transistors and 'Ferroxcube' inductors has enabled these stringent requirements to be fulfilled in an instrument patented under the name 'Apidictor'[1], of which a number have been constructed and are in regular use

Early models were portable, with a microphone on a probe, to be inserted in the entrance to the hive at the bottom of the brood-box This caused some disturbance, the stinging reaction, and also the instrument was necessarily close to the flight sound. Both these sounds are in the warble frequency-range, and considerable skill was needed to distinguish the

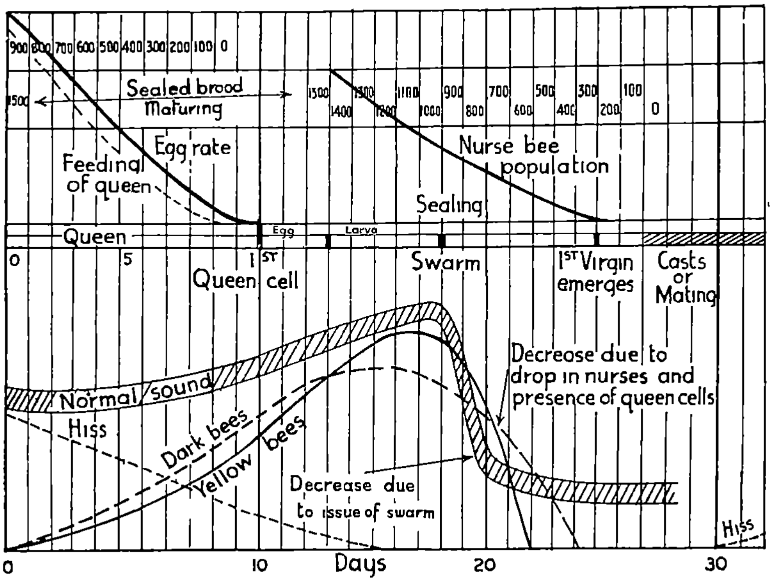

Fig 3 Swarm cycle

warble Furthermore, the warble 'radiates' from the queen, which is usually at the top of the brood-box, away from the entrance

Disturbance was eliminated, and the relative volume of the warble increased by placing a microphone permanently inside the hive at the top, but the adverse conditions of heat and humidity destroyed the (crystal) microphone fairly quickly, and the running cost of one microphone per hive per season was excessive

A scheme which has proved successful and economical utilizes a hole in the back of the brood-box at the top, with an internal screen of perforated zinc, and plugged with a rubber bung This bung is removed and the microphone, mounted in an identical bung, plugged in This third plan also removes a disadvantage of the second, namely, the variability of microphones, especially after some weeks in the hive

Headphones, of the familiar stethophone pattern, are used as a detector, but later development may permit the use of a visual indicator, at an increased cost An automatic alarm system is also possible for use in large centralized apiaries

The 'Apidictor' was primarily visualized as a swarm predictor, for which it has obvious economic advantages, but it has a great range of other uses It removes almost completely the uncertainty of queen introduction and queen cell acceptance, it detects abnormalities such as queen failure, that is, drone breeding, and it enables an accurate check to be made of the health of the colony in winter, even during heavy frost[1]

I wish to acknowledge the enthusiastic and skilled co-operation of many friends, but particularly of Mr E F Birch of Hereford, who has been working with me since 1951, and of Mr C B Dennis of Harrow, who has co-operated with me for the past three years I also wish to thank Messrs Wayne Kerr Laboratories of Surrey, for invaluable technical assistance

[1] British Patent No 729,067 (1958)

SEARCHING FOR INTERSTELLAR COMMUNICATIONS

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No theories yet exist which enable a reliable estimate of the probabilities of (1) planet formation , (2) origin of life , (3) evolution of societies possessing advanced scientific capabilities In the absence of such theories, our environment suggests that stars of the main sequence with a lifetime of many billions of years can possess planets, that of a small set of such planets two (Earth and very probably Mars) support life, that life on one such planet includes a society recently capable of considerable scientific investigation The lifetime of such societies is not known , but it seems unwarranted to deny that among such societies some might maintain themselves for times very long compared to the time of human history, perhaps for times comparable with geological time It follows, then, that near some star rather like the Sun there are civilizations with scientific interests and with technical possibilities much greater than those now available to us

To the beings of such a society, our Sun must appear as a likely site for the evolution of a new society It is highly probable that for a long time they will have been expecting the development of science near the Sun We shall assume that long ago they established a channel of communication that would one day become known to us, and that they look forward patiently to the answering signals from the Sun which would make known to them that a new society has entered the community of intelligence What sort of a channel would it be ?

The Optimum Channel

Interstellar communication across the galactic plasma without dispersion in direction and flight-time is practical, so far as we know, only with electromagnetic waves

Since the object of those who operate the source is to find a newly evolved society, we may presume that the channel used will be one that places a minimum burden of frequency and angular discrimination on the detector Moreover, the channel must not be highly attenuated in space or in the Earth's atmosphere Radio frequencies below ~ 1 Mc /s , and all frequencies higher than molecular absorption lines near 30,000 Mc /s , up to cosmic-ray gamma energies, are suspect of absorption in planetary atmospheres The band-widths which seem physically possible in the near-visible or gamma-ray domains demand either very great power at the source or very complicated techniques The wide radio-band from, say, 1 Mc to 10^4 Mc /s , remains as the rational choice

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In the radio region, the source must compete with two backgrounds (1) the emission of its own local star (we assume that the detector's angular resolution is unable to separate source from star since the source is likely to lie within a second of arc of its nearby star) , (2) the galactic emission along the line of sight

Let us examine the frequency dependence of these backgrounds A star similar to the quiet Sun would emit a power which produces at a distance R (in metres) a flux of

$$10^{-15} f^2/R^2 \quad \mathrm{W\ m^{-2} (c\ /s\ )^{-1}}$$

If this flux is detected by a mirror of diameter l_d, the received power is the above flux multiplied by $l_d{}^2$

The more or less isotropic part of the galactic background yields a received power equal to

$$\left(\frac{10^{-12.5}}{f}\right) \left(\frac{\lambda}{l_d}\right)^2 (l_d)^2 \quad \mathrm{W\ (c\ /s\ )^{-1}}$$

where the first factor arises from the spectrum of the galactic continuum, the second from the angular resolution, and the third from the area of the detector Thus a minimum in spurious background is defined by equating these two terms The minimum lies at

$$f_{\min} \approx 10^4 \left(\frac{R}{l_d}\right)^{0.4} \mathrm{c\ /s}$$

With $R = 10$ light years $= 10^{17}$ m and $l_d = 10^2$ m $f_{\min} \approx 10^{10}$ c /s

The source is likely to emit in the region of this broad minimum

At what frequency shall we look ? A long spectrum search for a weak signal of unknown frequency is difficult But, just in the most favoured radio region there lies a unique, objective standard of frequency, which must be known to every observer in the universe the outstanding radio emission line at 1,420 Mc /s (λ = 21 cm) of neutral hydrogen It is reasonable to expect that sensitive receivers for this frequency will be made at an early stage of the development of radio-astronomy That would be the expectation of the operators of the assumed source, and the present state of terrestrial instruments indeed justifies the expectation Therefore we think it most promising to search in the neighbourhood of 1,420 Mc /s

Power Demands of the Source

The galactic background around the 21-cm line amounts to

$$\frac{\mathrm{d}W_b}{\mathrm{d}S\ \mathrm{d}\Omega\ \mathrm{d}f} \approx 10^{-21.5} \quad \mathrm{W\ m^{-2}\ ster^{-1}\ (c\ /s\ )^{-1}}$$

for about two-thirds of the directions in the sky In the directions near the plane of the galaxy there is a background up to forty times higher It is thus economical to examine first those nearby stars which are in directions far from the galactic plane

If at the source a mirror is used l_s metres in diameter, then the power required for it to generate in our detector a signal as large as the galactic background is

$$\frac{\mathrm{d}W_s}{\mathrm{d}f} = \frac{\mathrm{d}W_b}{\mathrm{d}S\ \mathrm{d}\Omega\ \mathrm{d}f} \left(\frac{\lambda}{l_s}\right)^2 \left(\frac{\lambda}{l_d}\right) R^2 = 10^{-24.2} R^2/l_s{}^2 l_d{}^2 \quad \mathrm{W\ (c\ /s\ )^{-1}}$$

For source and receiver with mirrors like those at Jodrell Bank ($l = 80$ m), and for a distance $R \simeq 10$ light years, the power at the source required is $10^{2.2}$ W (c /s)$^{-1}$, which would tax our present technical possibilities However, if the size of the two mirrors is that of the telescope already planned by the U S Naval Research Laboratory ($l = 200$ m), the power needed is a factor of 40 lower, which would fall within even our limited capabilities

We have assumed that the source is beaming towards all the sun-like stars in its galactic neighbourhood The support of, say, 100 different beams of the kind we have described does not seem an impossible burden on a society more advanced than our own (Upon detecting one signal, even we would quickly establish many search beams) We can then hope to see a beam toward us from any suitable star within some tens of light years

Signal Location and Band-Width

In all directions outside the plane of the galaxy the 21-cm emission line does not emerge from the general background For stars in directions far from the galactic plane search should then be made around that wave-length However, the unknown Doppler shifts which arise from the motion of unseen planets suggest that the observed emission might be shifted up or down from the natural co-moving atomic frequency by $\pm \sim 300$ kc /s (± 100 km s^{-1}) Closer to the galactic plane, where the 21-cm line is strong, the source frequency would presumably move off to the wing of the natural line background as observed from the direction of the Sun

So far as the duration of the scanning is concerned, the receiver band-width appears to be unimportant The usual radiometer relation for fluctuations in the background applies here, that is

$$\frac{\Delta B}{B} \propto \sqrt{\frac{1}{\Delta f_d\, \tau}}$$

where Δf_d is the band-width of the detector and τ the time constant of the post-detection recording equipment On the other hand, the background accepted by the receiver is

$$B = \frac{\mathrm{d}W_b}{\mathrm{d}f} \Delta f_d \text{ and } \tau \propto \frac{\Delta f_d}{(\Delta B)^2}$$

If we set ΔB equal to some fixed value, then the search time T required to examine the band F within which we postulated the signal to lie is given by

$$T = \frac{F\tau}{\Delta f_d} \propto \frac{F}{(\Delta B)^2}$$

independent of receiver band-width Δf_d

Of course, the smaller the band-width chosen, the weaker the signal which can be detected, provided $\Delta f_d \gg \Delta f_s$ It looks reasonable for a first effort to choose a band-width Δf_d normal in 21 cm practice, but an integration time τ longer than usual A few settings should cover the frequency range F using an integration time of minutes or hours

Nature of the Signal and Possible Sources

No guesswork here is as good as finding the signal We expect that the signal will be pulse-modulated with a speed not very fast or very slow compared to a second, on grounds of band-width and of rotations A message is likely to continue for a time measured in years, since no answer can return in any event for some ten years It will then repeat, from the beginning. Possibly it will contain different types of signals alternating throughout the years For indisputable identification as an artificial signal, one signal might contain, for example, a sequence of small prime numbers of pulses, or simple arithmetical sums

The first effort should be devoted to examining the closest likely stars Among the stars within 15 light years, seven have luminosity and lifetime similar to those of our Sun Four of these lie in the directions of low background They are τ Ceti, 0_2 Eridani, ε Eridani, and ε Indi All these happen to have southern declinations Three others, α Centauri, 70 Ophiucus and 61 Cygni, lie near the galactic plane and therefore stand against higher backgrounds There are about a hundred stars of the appropriate luminosity among the stars of known spectral type within some fifty light years All main-sequence dwarfs between perhaps $G0$ and $K2$ with visual magnitudes less than about +6 are candidates

The reader may seek to consign these speculations wholly to the domain of science-fiction We submit, rather, that the foregoing line of argument demonstrates that the presence of interstellar signals is entirely consistent with all we now know, and that if signals are present the means of detecting them is now at hand Few will deny the profound importance, practical and philosophical, which the detection of interstellar communications would have We therefore feel that a discriminating search for signals deserves a considerable effort The probability of success is difficult to estimate , but if we never search, the chance of success is zero

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METABOLIC CHANGES INDUCED IN MAMMALIAN ERYTHROCYTES BY WHOLE-BODY X-IRRADIATION

By Prof D. A RAPPOPORT and B. W. SEWELL

Department of Biochemistry, Baylor University College of Medicine, Houston, Texas

APPLICATION of X-rays and radium in medicine, after their discovery during 1895–96, established their effectiveness in diagnosis and treatment of disease Only somewhat later were the lethal and injurious properties of these penetrating rays recognized[1] Since then, large groups of men have become exposed more frequently to man-made radiation These additional exposures to penetrating radiation have magnified the need for a reliable indicator of radiation-induced tissue damage What is precisely needed is a simple and accurate indicator which would correlate biological damage with the radiation dose[1]

The requirements of an ideal biological radiation indicator are that (*a*) a tissue or tissue component should show changes over extended periods following whole-body irradiation , (*b*) this change can be quantitatively measured It is also important that tissue samples should be available for intermittent sampling without injury to the subject and without alteration in the system under examination

Choice of Erythrocytes

Certain generalizations can be used in considering this problem in order to initiate a working hypothesis Tentatively it can be assumed that any radiation absorbed by cells will cause changes in the cell enzymes[2], but that the detection of these changes is dependent on (*a*) the sensitivity to radiation of a particular enzyme system under evaluation and (*b*) the degree of sensitivity of the analytical methods employed

Implicit in the above specifications is the fact that the tissue must be incapable of extensive internal repair if it is to reflect any post-irradiation changes This immediately eliminates tissues with large populations of mitotic cells and suggests erythrocytes as the tissue component of choice In man the erythrocyte has a life-span of 110–120 days[3], in the rat this span is 49–55 days[4], in other mammals erythrocyte life-spans are between these values[5] Since mammalian erythrocytes are enucleated, no resyntheses of proteins can occur, and any radiation damage incurred on the enzyme-proteins, such as denaturation or rupture of peptide linkage, should be detectable by changes in enzymic reactions This rationale suggests the erythrocyte enzymes for examination as a test system

If the hypothesis is held that any absorbed radiation will affect enzymes in all cells, how is it that no enzymic changes have been observed in erythrocytes after moderate whole-body irradiation ? This may be explained on the basis that up to the present time few erythrocyte enzymes have been tested after radiation treatment Erythrocyte enzymology has now been more thoroughly explored[6,7] With the complete elucidation of glycolysis, the hexosemonophosphate shunt, the transketolase and transaldolase enzymes, and nucleoside phosphorylase in erythrocyte extracts, re-examination of the radiation effect on these enzyme systems is in order

Nucleoside Metabolism

Investigators concerned with the preservation of blood have found that when inosine or adenosine is added to blood the integrity of the erythrocytes is maintained during storage and their survival following transfusion is improved[8] This was attributed to the resynthesis of metabolites essential for erythrocyte integrity

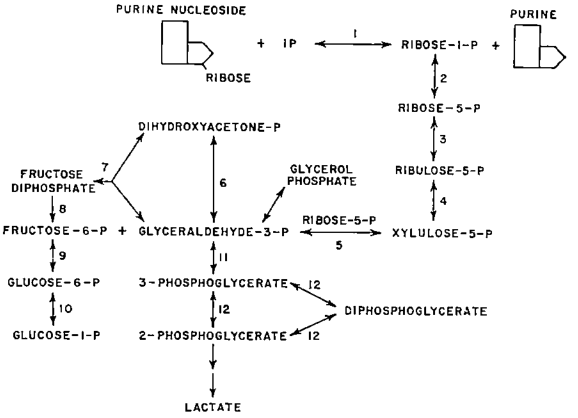

Fig 1 Diagrammatic representation of the metabolic reactions of purine nucleosides in erythrocytes The enzymes involved are (1) nucleoside phosphorylase, (2) phosphoribomutase, (3) phosphoriboisomerase, (4) phosphoketopentoepimerase, (5) transketolase, (6) triosephosphate isomerase, (7) aldolase, (8) fructose diphosphatase, (9) phosphoglucoisomerase, (10) phosphoglucomutase, (11) triosephosphate dehydrogenase, (12) phosphoglyceric mutase

The enzymes responsible for nucleoside metabolism within the erythrocyte are in the soluble portion of the cell The reactions which they catalyse are diagrammatically illustrated in Fig 1 First, the nucleoside in presence of phosphate is converted to ribose-1-phosphate and a purine base by a nucleoside phosphorylase[9] Later, the pentose phosphate is transformed to a variety of phosphate esters via the actions of transketolase, transaldolase and the glycolytic enzymes[6]

When considering nucleoside metabolism in erythrocytes as a system for evaluation of X-ray effects, it can be assumed that if any enzyme among the group of interdependent reactions is inhibited there will be an accumulation of substrate and a change in the yield of phosphate esters Complex multiple enzyme systems, such as are involved in erythrocyte metabolism of nucleosides, have certain disadvantages as well as advantages in studies of radiation effects The disadvantage in such systems is that it may be difficult to determine which particular enzyme was affected by the radiation However, the advantage n using a multiple enzyme system is that this ncreases the opportunity of finding one or more enzymes sensitive to absorbed radiation

Erythrocyte Turnover

In the studies on the enzymic changes at prolonged post-rradiation intervals, time of residence of the circulating erythrocyte is a major factor for consideration This requires that the maximum post-rradiation time-interval used for evaluation must be within the period when the irradiated erythrocyte population is not markedly altered This can be calculated from the erythrocyte life-span

Inbred strains of rats are convenient for radiological studies The 'mean life-span' of rat erythrocytes as well as the 'half-clearance time' can be used to estimate changes in erythrocyte population The mean life-span' of an erythrocyte is the average nterval of time any erythrocytes will remain in circulation, 'half-clearance time' is that time-nterval at which 50 per cent of the circulating erythrocytes will disappear from circulation Belcher and Harriss[4] have recently reported the 'mean life-span' of the rat erythrocyte as 49–55 days The 'half-clearance time' was determined as 20 7 ± 2 5 days

Since these observations are based on the mean life-span and half-clearance time of erythrocytes in the normal rats, it is important to know how these figures are altered in X-irradiated rats Total-body X-irradiation of rats in excess of 300 r causes complete inactivation of marrow and stops the extrusion of erythrocytes into circulation[10] However, the life-span and half-clearance time of the circulating erythrocytes remain relatively the same as in the unirradiated animals[11] There is evidence that random (non-senescent) destruction of erythrocytes, which in the normal rat is approximately 0 48 per cent per day[5,6], is increased in the irradiated animals but the magnitude of this change is unknown[11]

Recognizing the prolonged inactivation of marrow after an X-ray dose of 300 r or higher, we see that the erythrocyte population will consist only of irradiated cells up to and even beyond a two-week period, since no new cells are extruded by marrow during this time However, due to internal hæmorrhages and other undefined factors, random non-senescent loss of erythrocytes will be increased[11] This will cause a drop in the number of red cells, however, loss of plasma into tissue and dehydration due to vomiting and diarrhœa will tend to decrease plasma volume, hence there may be no net change in hæmatocrit values[11].

The above discussion can be summarized by the conclusion that following total-body radiation with doses at and above 300 r the erythrocyte population remains relatively undiluted and the life-span and half-clearance time remain approximately the same as in the unirradiated rat, with the exception that there is an increased random loss of erythrocytes which cannot be quantitatively evaluated at present

It is tentatively concluded that the erythrocyte is a promising tissue component as an internal mammalian X-ray indicator, since (*a*) it has a wide variety of enzymes among which some may be sensitive to radiation, (*b*) it cannot replace altered enzyme-proteins, (*c*) it has a long life-span even in irradiated animals, (*d*) it is accessible for repeated sampling

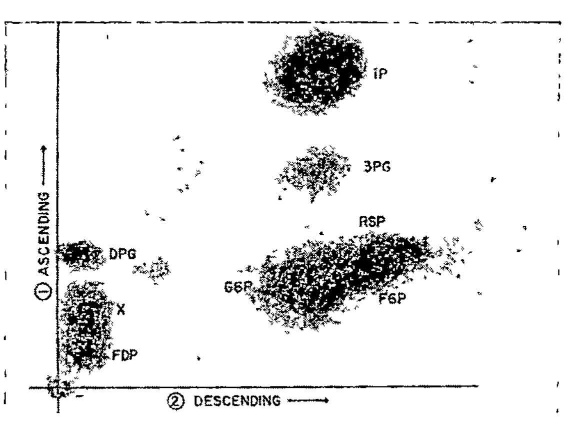

Fig 2 Radioautogram of phosphate esters separated by two-dimensional paper chromatography, (1) ascending with ethyl-acetate, acetic acid and water (3 3 1) and (2) descending with methyl ethyl ketone, methyl cellosolve, ammonia and water (7 2 0 7 2 3) *iP*, inorganic phosphate, *3PG*, 3-phosphoglycerate, *R5P*, ribose-5-phosphate, *G6P*, glucose-6-phosphate, *DPG*, 2,3-diphosphoglycerate, *X*, unidentified ester, *FDP*, fructose diphosphate

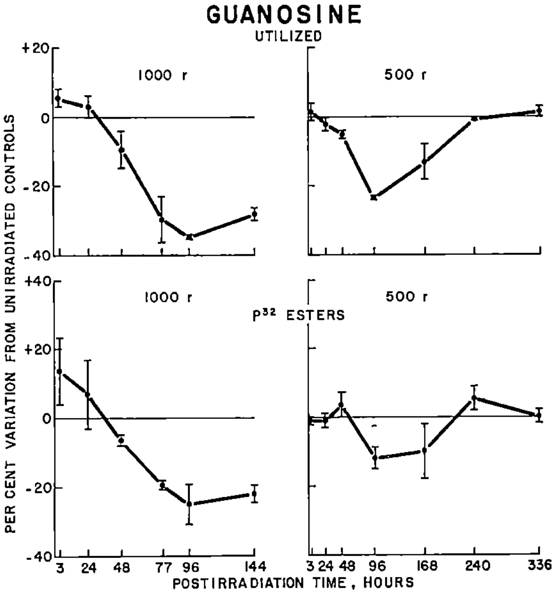

Fig 3 Comparative utilization of guanosine and formation of phosphate esters by rat erythrocyte extracts from rats irradiated with 1,000 and 500 r X-rays, respectively

The concepts discussed above were tested by measuring the changes in nucleoside metabolism by erythrocyte extracts from irradiated and unirradiated rats Our results established that following 1,000 r whole-body X-irradiation the utilization of purine nucleosides was markedly depressed up to 144 hr after irradiation Whole-body irradiation of 500 r also depressed purine nucleoside metabolism for a period of 96 hr, when the metabolism began to increase and by 240 hr reached the level of substrate utilization by erythrocyte extracts from unirradiated controls These results establish that erythrocyte enzymes are affected by moderate whole-body radiation and that these changes are detectable over a period from one to two weeks after irradiation

Experimental Results

Erythrocytes from irradiated and unirradiated Sprague–Dawley rats were separated from white cells and plasma, lysed in water dialysed overnight, extracts were then prepared by centrifugation These extracts were incubated for 2 hr in *tris* buffer at *p*H 7 4 with either guanosine inosine, or adenosine in the presence of inorganic phosphate labelled with phosphorus-32 and magnesium chloride The detailed procedures and techniques will be described elsewhere[12] After incubation, the remaining purine nucleoside was analysed, total organic phosphate was determined, and the nature of the individual phosphate esters formed was established by means of paper chromatography[13]

The reactions studied in these incubations are represented schematically in Fig 1 and the phosphate esters actually formed from guanosine and labelled inorganic phosphate are shown by the radioautogram in Fig 2 The same phosphate esters were also obtained from incubations of inosine and adenosine Enzyme activity of erythrocyte extracts from rats irradiated with 1,000 r or 500 r to the whole body were compared with extracts from unirradiated controls A decrease in substrate utilization and phosphate ester formation was observed The results of these experiments are illustrated in Figs 3, 4 and 5

Erythrocyte extracts from rats treated with 1,000 r. showed enhanced utilization of guanosine up to 24 hr after irradiation (Fig 3), but afterwards both guanosine utilization and phosphate ester formation decreased and at 96 hr reached a minimum value and remained at this level until the death of the animals in 7–8 days Extracts from the rats treated with 500 r. showed a decrease in guanosine utilization in 24 hr after irradiation and this reduced enzyme activity continued until the ninety-sixth hour (Fig 3, these are similar to the results with the 1,000 r extracts) Afterwards, the utilization of guanosine increased again and in 240 hr the level of substrate utilization was equal to that of the controls Almost identical results were obtained with inosine, as shown in Fig 4 However, utilization of inosine by erythrocyte extracts from 500 r treated rats did not reach the level of inosine utilization by the controls until 336 hr after irradiation Experiments with adenosine utilization showed results similar to those of inosine

Significance of Results

These experiments establish that erythrocyte enzymes are affected by lethal (1,000 r) and sub-lethal (500 r) whole-body X-irradiation Also the inhibitory effect of radiation persists for seven days or longer depending on the X-ray dose Since the same enzymes are involved in the metabolism of guanosine, inosine or adenosine, one would expect radiation to influence these reactions in a similar way, as they did (Figs 3, 4 and 5)

Although nucleoside metabolism by the erythrocyte extracts from rats treated with 1,000 r was inhibited during their survival (7–8 days), the extracts from the rats treated with 500 r X-rays showed a marked inhibition for the initial interval up to 7 days after radiation This was followed by the recovery of enzyme activity by 7–10 or 14 days post-irradiation This recovery of activity suggests that with 500 r whole-body radiation the inhibition was not due to

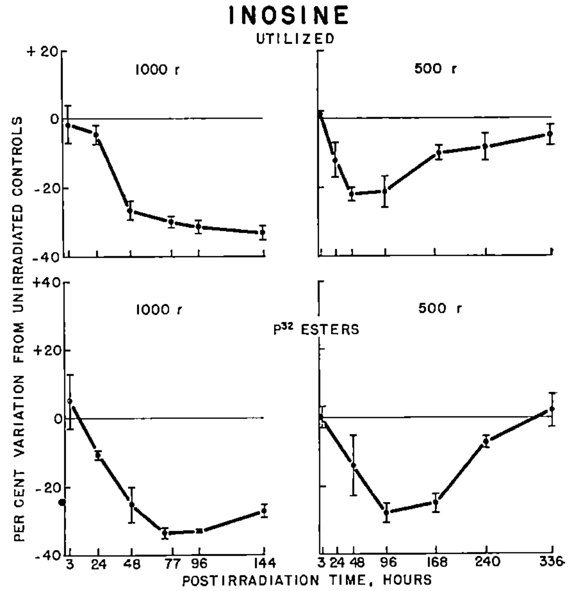

Fig 4 Comparative utilization of inosine by rat erythrocyte extracts

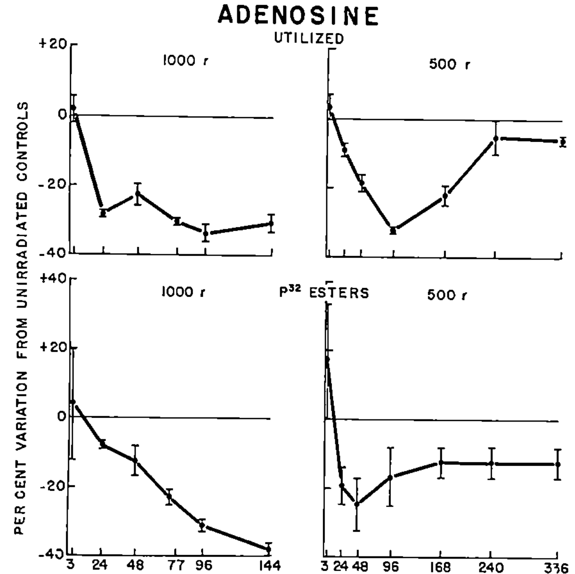

Fig 5 Comparative utilization of adenosine by rat erythrocyte extracts

irreversible protein damage, but probably to the oxidation of some essential sulphydryl groups to disulphides Since the erythrocytes contain glutathione, it is likely that the disulphide groups were gradually reduced by the glutathione during the period of recovery of enzyme activity

Although the radiation does affect the erythrocyte metabolism, how useful is this information in evaluating erythrocyte metabolism as a biological radiation indicator ? Data from Figs 3, 4 and 5 also show that the degree of inhibition, particularly for guanosine and inosine metabolism (Figs 3 and 4), is appreciably greater at 48 hr after 1,000 r irradiation than after 500 r treatment Adenosine metabolism decreased in 24 hr to a greater extent in the rats treated with 1,000 r than in those receiving 500 r The variations in erythrocyte activity described above following 1,000 r and 500 r irradiation are only the initial observations Additional data will be necessary to establish the relationship between whole-body radiation dose and degree of enzyme inhibition in erythrocyte extracts The present results suggest that the metabolism of nucleosides following radiation can serve as a gross biological indicator This information may encourage other investigators to examine the erythrocyte metabolism in other species, particularly cancer patients requiring total-body radiation treatment, in order to ascertain whether X-ray induced inhibition of rat erythrocyte metabolism also occurs in other animals, as well as in man

This research was supported by Army Contract *DA*-49-007-*MD*-428(*SGO*)

We gratefully acknowledge the discussions and suggestions on the preparation of this manuscript to Dr C T Teng, Department of Radiology, and Dr F B Moreland, Department of Biochemistry, Baylor University College of Medicine

[1] Speak, F G , *Intern Rev Cytol* , **7**, 1 (1958)
[2] Bacq, Z M , and Alexander, P , "Fundamentals of Radiobiology", 228 (Academic Press, New York, 1955)
[3] Shemin, D , and Rittenberg, D *J Biol Chem* , **166**, 627 (1946)
[4] Belcher, E H , and Harriss, E B , *J Physiol* , **146**, 217 (1959)
[5] Brown, jun , I W , and Eadie, G S , *J Gen Physiol* , **36**, 327 (1953)
[6] Dickens, F , *Ann N Y Acad Sci* , **75**, 71 (1958)
[7] Prankerd, T A J , *Intern Rev Cytol* , **5**, 279 (1956)
[8] Gabrio, B W , Finch, C A , and Huennekens, F M , *Blood*, **9**, 103 (1956)
[9] Kalckar, E , *J Biol Chem* , **158** 723 (1945)
[10] Baxter, C F , Belcher, E H , Harriss, E B , and Lamerton, L F , *Brit J Hæmat* , **1**, 86 (1955)
[11] Jacobson, L O , in "Radiation Biology", A Hollænder, ed , 1036 (McGraw-Hill, New York, 1954)
[12] Rappoport, D A , Sewell, B W , and Chen, P T (in preparation)
[13] Rappoport, D A , and Chen, P T (in preparation)

THE CHEMISTRY OF CLOTHING*

EVEN though clothing is one of the essential needs of human beings, it is only some fifty years since chemists and physicists, in their professional capacity, first began to give any serious thought to the subject, or even to the textile fabrics from which most clothes are made Almost everyone is, of course, interested in the æsthetics of clothing, and the fashion and style of garments often reflect the spirit of the times In the past half-century, however, quite outstanding progress has been made, not only in providing new materials for garments, but also in understanding more precisely what is required of clothing to be worn under various climatic conditions It was fitting, therefore, that at the York meeting of the British Association one session of Section B (Chemistry) was devoted to a symposium entitled "The Chemistry of Clothing"

The scope of the symposium was rather wider than its title implied, for much of the work which has been carried out is more accurately described as applied physics The principles on which the comfort and usefulness of clothing are based were discussed by Mr W H Rees of the British Cotton Industry Research Association He pointed out that in cold climates clothing acts as an insulator, thereby reducing heat lost from the body to a level which can be counterbalanced by body metabolism Since textile fibres are better conductors than air, the greater the amount of air entrapped by a fabric the more effective will it be as an insulator Rees indicated that only about 6 per cent of the volume of a blanket is occupied by fibres, the remainder being air In more compact structures this volume of air is reduced, but in most apparel fabrics it is of the order of two-thirds It is important that the entrapped air should be undisturbed and, consequently, apparel fabrics for use in windy weather should be constructed so that the wind is kept out Again, if the air in the fabric is replaced by water, as in heavy rain, the efficiency of the fabric as an insulator will fall According to Rees, therefore, clothing to be worn in wet, windy conditions should comprise "a windproof, waterproof and vapour permeable outer garment and an ample supply of inner garments having a large air content".

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* Based on the following four papers presented at the York meeting of the British Association for the Advancement of Science
"Physical Aspects of Clothing for Comfort", by Mr W H Rees British Cotton Industry Research Association)
"The Chemical Treatment of Apparel Fabrics", by Prof C S Whewell (professor of textile technology, University of Leeds)
"Recent Advances in the Application of Cellulosic Man-Made Fibres to Clothing", by Dr H A Thomas (Messrs Courtaulds, Ltd)
"The Use of Synthetic Hydrophobic Fibres in Clothing", by Mr B Thompson (Messrs Imperial Chemical Industries, Ltd , Fibres Division)

Body heat is also lost by radiation in the far infra-red region. All textiles, whatever their colour, are virtually black bodies, with high emissivities, at least ten times as great as that of a metallic surface. To minimize radiation losses garments have, therefore, been lined with aluminium foil. The heat loss is markedly reduced, but if the layer of foil is continuous, the fabric becomes harsh and unsatisfactory and is impermeable to water vapour. By an ingenious method of perforating the film, however, it has been possible to produce in the laboratories of the British Cotton Industry Research Association a fabric which has the usual textile properties but which is extremely effective in cutting down losses by radiation.

In hot climates clothing must reflect away solar radiation and assist in keeping the body cool by the evaporation of sweat. Reflexion of radiation is clearly determined partly by the colour of the fabric, lighter coloured materials being the more effective. A white fabric will reflect away two-thirds of the incident radiation and a black one only about one-tenth. Mr. Rees has also examined the reflecting power of cotton fabrics dyed the same colour but with different types of dyes, and has found considerable differences in the infra-red. This indicates that although the reflecting power for radiations in the visible region are the same for all the fabrics, those in the infra-red are different. The chemical constitution of the dye is, therefore, important in determining the reflecting power of dyed fabrics. As would be expected, fabrics coated with aluminium foil are excellent reflectors, and if they are produced by the British Cotton Industry Research Association technique their textile properties are not impaired. In addition to being good reflectors, hot weather garments should also assist in the evaporation of sweat, and those worn next to the skin should, therefore, be absorbent and of open structure.

Modern clothing must have many characteristics other than that of being comfortable to wear. It must be æsthetically satisfying and must often have specific properties such as being fireproof, lustrous, mothproof or waterproof. In addition it must retain its appearance and essential properties during wear and after being washed or dry-cleaned. The necessity for garments to retain their essential properties throughout their life is becoming increasingly important and was stressed several times during the symposium.

Although some garments are made from skins, leather, felt and plastics, most are made from knitted, woven or bonded textiles. Fabrics available to the clothing manufacturer may contain both natural and man-made fibres. Garment manufacturing has been, however, largely based on natural fibre fabrics, but with the advent of man-made fibres, the resources of the clothing designer have been greatly increased, for there is an ever-growing production of new fibres and fabrics with interesting and novel characteristics. It was clearly not possible to discuss in the symposium new developments in all types of synthetic fibres and attention was concentrated upon specific fibre types. It must be stressed, however, that progress in the production of other fibres, for example, the acrylics, the polyolefines, and those based on fully acetylated cellulose, has been equally rapid. The development of man-made fibres has made possible the production of fabrics and garments with performance characteristics formerly considered to be unattainable. Of particular importance has been the production of fabrics which are light in weight but yet are strong and durable, and of fabrics which are easily washed and do not require ironing to restore their attractive appearance. These developments have, of course, stimulated research in the treatment and modification of fabrics made from natural fibres so that these materials also can be given some of the attractive characteristics of fabrics made from the newer fibres.

The man-made fibres can be divided into two groups—those which absorb considerable amounts of moisture, for example, viscose rayon, and those which do not, such as 'Terylene' and nylon.

Older forms of viscose rayon had several defects but now a wide range of improved regenerated cellulose fibres can be obtained. It is well known that fibres made by the viscose process have a 'skin and core' structure. The ratio between the amounts of skin and core may, however, be altered by controlling the conditions of xanthation and coagulation, and other desirable properties can be given to the filaments by stretching them immediately after they have been formed. Some of the newer products obtained by such techniques have extremely interesting properties. For example, fibres composed entirely of 'skin' are exceptionally tough and resistant to abrasion wet or dry, being stronger than cotton when wet. Filaments which are all core are obtained by spinning into a solution of ammonium sulphate and stretching the filaments by 50–100 per cent. These filaments are characterized by high strength and low extensibility when wet and are useful for making fabrics which do not shrink or stretch when they are washed. Moreover, by adjusting the spinning conditions so that one side of the fibre has a thick skin and the other a thin skin, asymmetric fibres are obtained. Because of the different swelling properties of the two sides, these fibres are crimped, and even if the crimp is pulled out during processing it will reappear on afterwards wetting the fibre. Provided that appropriate stable pigments can be ground sufficiently finely to prevent blocking the holes in the spinnerets, 'spun dyed' fibres can be produced by almost any spinning process by incorporating the pigment in the dope before it is extruded. The spun-dyed viscose rayons have been found to have some unexpected properties, for not only are the colours very fast to repeated washing and to exposure to bright sunlight, but the dispersed pigments also protect the fibre from photodegradation and deterioration in industrial atmospheres.

The introduction of the hydrophobic apparel fibres was a great step forward in textile science and technology. As Mr. A. B. Thompson pointed out, a good textile fibre must be soft without being too extensible, that is to say, it must be intermediate between a glass and a rubber. It must be elastic rather than plastic, although a plastic state is needed to ensure a satisfactory response to ironing and pressing which are essential in garment making, and often for the subsequent care of apparel fabrics. Natural fibres meet the latter requirements because they can be made plastic by application of heat and moisture. The hydrophobic fibres are much less affected by moisture and consequently retain their elasticity during use, and to achieve the plastic state heat is necessary. In general, therefore, the elastic state required in use and the plastic state needed for ironing, etc, are quite distinct This separation of the semi-flexible elastic state required in use from the more flexible plastic state needed for shaping and pressing enables garments made from the hydrophobic fibres to retain their smart appearance during wear and to be pressed or creased permanently when required

Each natural or man-made fibre has its own characteristics Many apparel fabrics are therefore made from blends of different fibres, the blend being selected so that advantage is taken of the desirable properties of each of the components Of particular significance is the blending of hydrophobic and hydrophilic fibres to produce fabrics which are light, durable, and easily cared-for, but yet comfortable to wear

Almost all fabrics are improved by suitable chemical treatment The changes brought about must, however, be 'permanent' Processes of this type were discussed by Prof C S Whewell, emphasis being laid on developments in the production of crease-resistant, 'drip-dry' and 'minimum-care' fabrics, the permanent pleating of wool fabrics, methods for obtaining textile fabrics which do not shrink or expand when they are washed, and the production of fabrics which are permanently mothproof, fireproof and waterproof

The four papers presented at the symposium formed a useful indication of some of the important trends in the production of better apparel fabrics and garments The craft of the tailor and the cloth designer is now being supplemented by the skill and resources of the scientist This combined approach to the problems associated with clothing is comparatively new, but the success which has so far been achieved is ample proof of the value of the collaboration The opportunities for research and development in this field are indeed exciting Perhaps a future meeting of the British Association will be the occasion on which the results and achievements will be discussed C S WHEWELL

RESEARCH IN THE ANTARCTIC DURING 1960

British Programme

THE Falkland Islands Dependencies Survey maintains a number of permanent scientific stations within the Falkland Islands Dependencies sector of the Antarctic Many of these have been in continuous occupation since 1944 During the International Geophysical Year they played their part with the stations of other nations in the general co-ordinated plan At the end of 1958, the Royal Society station at Halley Bay was handed over to the Survey and will continue to work like that of the other stations of the Falkland Islands Dependencies Survey, into the indefinite future

The main geophysical stations are at the Argentine Islands and Halley Bay, the two being separated by about 1,000 miles At both, daily upper-air soundings will continue, as will the surface meteorological work which is common to all bases except Port Lockroy Fluxplates and solarimeters will be in use for the study of radiation balance, and both stations will continue ozone observations using the Dobson spectrophotometer

The ionospheric work at Port Lockroy, only 40 miles from the Argentine Islands, will continue in operation, as will the recording of whistlers which forms a part of the programme initiated from Dartmouth College, New Hampshire

At Halley Bay the ionospheric equipment was not in use last year but is to be brought into commission again for 1960 On the other hand, it has been decided to abandon the seismological work there, but to continue using the Willmore short-period seismographs at the Argentine Islands

Because of the geomagnetic latitudes of the stations of the Falkland Islands Dependencies Survey, very few auroral displays are observed except at Halley Bay There an all-sky camera will continue in operation, and other studies include a small glaciological programme, observations of sea ice growth and of the measurements of marine currents

In the coming year an attempt will be made to recover cosmic spherules falling on the ice sheet, and also to obtain samples from deep within the ice Since there can be no dilution by other sedimentary materials, it may prove possible to determine a rate of deposition for this cosmic material

The other bases extend from South Georgia, where there is a purely meteorological station, through the South Orkneys and the South Shetlands along the coast of Graham Land to about lat 68° S All are manned throughout the year, the number of men varying between five and eighteen During the summer, work is to be carried out from the ships operating in the area These will be R R S *John Biscoe*, R R S *Shackleton*, H M S *Protector* and the Danish vessel *Kista Dan*, chartered for the season

John Biscoe will be committed almost entirely to relief and re-storing the bases, but it is hoped to operate a wave-recorder on board to investigate the damping effect of pack ice This is not only of academic interest, but will also be valuable when forecasting the break-up of the sea ice All bases maintain constant sea ice observations which already provide a background upon which seasonal probability charts are being built up If the protective effect of large areas of drifting pack can be assessed, ice forecasts for shipping will be materially assisted

Shackleton will be extending hydrographic surveys along the west coast of Graham Land and around the South Shetland Islands In addition, she has been fitted to tow a proton resonance magnetometer so that investigation of the Scotia Arc can be begun This work will tie up with the magnetic traverses already in progress from Hope Bay in the Trinity Peninsula area A Worden gravimeter will also be carried and put ashore for gravity observations at as many points as possible

H M S *Protector* carries helicopters and these will be used to extend the tellurometer survey where the landing of men and instruments cannot be made in any other way

The task of the *Kista Dan* is to re-establish the southernmost base on Stonington Island, which had to be evacuated last year because of bad ice conditions She will be carrying two aircraft which can be used for the transport of men and material, but if the ship is held up by bad ice conditions their first task will be to re-supply the base Then reconnaissance flights are to be made southward to select a site for a field hut which will be flown in at the end of the season Both aircraft will winter at the base and can therefore support field parties making topographical and geological surveys in the remoter regions during the early part of the 1960–61 season The *Beaver* aircraft is fitted with a Williamson vertical camera so that photographic cover can be obtained over the more inaccessible areas

Geological and topographic surveys will also continue from a number of other stations and, in addition to the glaciological programme at Halley Bay, glaciologists will be working from Hope Bay, Admiralty Bay and King George Island

In the coming year biological work will have less emphasis than in some years, but the marking and population counts of fur seals and elephant seals will continue A small project concerned with soil ecology is to begin at Signy Island Also at Halley Bay, where there is a rookery of 10,000 emperor penguins, a biologist has been appointed to continue the study of the species In particular, an examination of the endocrinology of the bird and a further collection of embryological material will be made

In each southern summer, ice conditions are different, and it is this which often hinders the planned programme Last year was a bad year, this year we hope for better things, but in any event it is certain that the only way to succeed is to keep up the pressure and be ready to take advantage of any relaxation which Nature may afford

VIVIAN FUCHS

American Programme

A STATEMENT released by the National Science Foundation gives details of grants for scientific investigations either in or associated with Antarctic regions Logistic support will again be the responsibility of a U S Navy support force under Rear Admiral David M Tyree, who has recently taken over from Rear Admiral George J Dufek The grants total 3,170,069 dollars, of which approximately one-third goes to support the meteorological programme and one-quarter to glaciological projects Greater emphasis than formerly is placed on geology, cartography and biology, which is in accord with the recommendations of the Special Committee on Antarctic Research of the International Council of Scientific Unions

Among new projects mentioned are a United States scientific expedition to the Bellinghausen Sea which will include specialists in biology, geology, cartography and oceanography

The International Geophysical Year pattern of over-snow traverse operations will be continued in Marie Byrd Land and Victoria Land Biological investigations on the ecology of the Ross Sea area and on land invertebrates of the McMurdo Sound and Hallett areas will be helped by the recently established U S Antarctic Biological Research Laboratory at McMurdo

The investigations will be spread over seven Antarctic stations of which three are fully and one jointly under the direction of the United States Co-operation with other countries in these investigations in both scientific and logistic spheres has been a notable feature of the U S Antarctic effort, and this appears likely to continue

NEWS and VIEWS

The Third Russian Space Rocket

A MULTI-STAGE space rocket was launched in the U S S R at about 02h U T on October 4 When the last stage, weighing 1,553 kgm (3,424 lb) without fuel, had reached a speed slightly less than escape speed from the Earth, an instrumented vehicle weighing 278 5 kgm (614 lb) separated from it This vehicle entered an elongated elliptic orbit which took it into the vicinity of the Moon Its nearest approach to the Moon occurred at 14h 16m U T on October 6, when it was about 7,000 km (4,300 miles) from the surface of the Moon, at selenographic longitude 137° W and latitude 12° S After leaving the vicinity of the Moon, the vehicle entered a new elliptic orbit about the Earth, with an apogee distance of 470,000 km (292,000 miles) from the surface of the Earth, attained at about 00h U T on October 11, and a perigee distance of 40,000 km (25,000 miles), attained at about 17h U T on October 18 The orbit is inclined at about 75° to the Earth's equator and the period of revolution is about 15 4 days The vehicle has been designated Earth-satellite 1959 θ The orbit of the spent rocket is not known The instrumented vehicle, which the Russians have referred to as an "automatic interplanetary station", carried apparatus to photograph the part of the Moon which is never seen from the Earth, and also apparently performed other scientific experiments, of which details have not yet been given The vehicle had radio transmitters operating on 39 986 Mc /s and 183 6 Mc /s, the power being supplied partly by chemical and partly by solar batteries

Research Association of British Paint, Colour and Varnish Manufacturers Dr L A Jordan, C B E

DR LOUIS ARNOLD JORDAN, the founder-director of the Research Association of British Paint, Colour and Varnish Manufacturers, has relinquished his appointment after thirty-three years The Paint Research Station at Teddington, at present being further extended, stands in testimony to his achievement Educated at Alderman Newton's Greencoat Foundation School, Leicester, he proceeded as a Royal scholar in 1910 to the Royal College of Science, where he was Tyndall prize-man in physics and Frank Hatton prize-man in chemistry He received the D Sc (London) in 1921 During the First World War he was concerned with explosives, and certain 'gas' problems, thence to Boots Pure Drug Co, Ltd, and later to the British Xylonite Co, Ltd, to start an investigation which resulted in the establishment of the British synthetic camphor industry From 1923 until the establishment of the Paint Research Association in 1926 he was scientific adviser to the State of Bhopal, Central India. He returned to India in 1955 at the invitation of the Government of India to inquire into matters touching the development of the lac industries. In fact, he is widely travelled (another recent journey having been to Brazil to advise on organized research in paint and related matters) and is well known internationally, for example, through his work for the Organic Coatings Division of the Applied Chemistry Section of the International Union of Pure and Applied Chemistry.

Dr Jordan has given extensive service to the Oil and Colour Chemists Association (he was president during 1947–49) and to numerous other scientific and technical organizations. He was chairman of the council of the Society of Chemical Industry during 1952–53 and medallist of the Society in 1953. As one of the Jubilee Memorial lecturers of the Society (1944) he chose as his subject "Paint, the Art and Science", reflecting his interest in the artistic as well as in the industrial and scientific aspects of paint and painting, an interest culminating in 1958 in his appointment as professor of chemistry at the Royal Academy of Arts. His work for technical education stands high in achievement and personal satisfaction. He has for long been chairman of the City and Guilds Advisory Committee on Paint Technology, and his period as a Surrey county councillor (1946–58) provided opportunities for contributions in a wider field of technical studies. He is now chairman of the governors of the Kingston Technical College, a governor of the Brunel College of Technology, and a member of the Regional Advisory Council for Technological Education for London and the Home Counties Region. He has recently been appointed to the senate of the University of London.

Botany at Hull

Prof R D'O Good

Prof Ronald Good, who has retired from the chair of botany in the University of Hull, was head of the Department of Botany from the foundation of the University College in 1928. After serving in the First World War, followed by a brilliant period at Downing College, Cambridge, he held an appointment at the British Museum (Natural History). At Hull he had much to do with the organization and equipment of his department, as well as teaching, but he has also been active as a researcher and writer. His book on the "Geography of the Flowering Plants" has had a wide circulation and is regarded as one of the chief works on the subject, while his "Handbook of the Dorset Flora" is an outstanding ecological study.

Prof N F Robertson

Dr N F Robertson, who has succeeded Prof Good, has been on the staff of the Cambridge Botany School since 1948. His interest in mycology was first aroused by Dr Malcolm Wilson at the University of Edinburgh. After graduating there in 1944, Dr Robertson was appointed a Colonial Office probationer and studied at the University of Cambridge, at Rothamsted Experimental Station and in the United States before proceeding to the West African Cacao Research Institute at Tafo late in 1946. He worked there, in collaboration with Dr A F Posnette, on insect transmission of the swollen shoot disease. Dr Robertson's first research problem at Cambridge was concerned with mycorrhizal infection of the Scots pine, and he made a notable contribution to the subject by showing that the behaviour of the mycorrhizal fungus was closely related to that of the specialized root disease fungi affecting tree crops. More recently, Dr Robertson has turned his attention to the physiology of fungal branch systems in culture, and has made what may eventually prove to be the first experimental approach to the morphogenesis of asexual spore production. With his research students, Dr Robertson has explored a much wider field, ranging from the physiology and genetics of the Fusaria in laboratory experiments to the behaviour of Fusarium wilt diseases and potato blight in the field. The University of Hull is doubly fortunate in securing Dr Robertson as professor of botany, because he has distinguished himself at Cambridge not only by his research but also as a teacher, and by the full share he has taken in other duties in the Department of Botany, where he will be greatly missed.

The World Veterinary Association

Prof W. I B Beveridge

At the recent International Veterinary Congress in Madrid a World Veterinary Association was established. The main purposes of the Association are to unify the veterinary profession throughout the world by providing a central link for national veterinary associations, and the exchange of information on matters of veterinary interest. The organs of the Association are the congress and the permanent committee.

Prof W I B Beveridge, professor of animal pathology, University of Cambridge, has been elected president of the Permanent Committee of the newly founded World Veterinary Association. He has had a distinguished career as a veterinarian who gave outstanding service to his profession in Australia and in the United Kingdom. After graduating at the University of Sydney, he was a member of the research staff of the McMaster Animal Health Laboratory in Sydney during 1931–41. During two years of that time he was the holder of a Commonwealth Fund Fellowship at the Rockefeller Institute, Princeton, and the Bureau of Animal Industry, Washington. From 1941 until his appointment as professor of animal pathology in Cambridge he worked at the Walter and Eliza Hall Institute in Melbourne. Together with Sir Macfarlane Burnet he worked on viral diseases in man and published several outstanding papers concerning cultivation of viruses. In Cambridge, Prof Beveridge's researches are mainly concerned with viral diseases of respiratory systems in animals. Unfortunately, his scientific work there was very much interrupted by administrative duties associated with the establishment of the new Veterinary School which was opened by H M the Queen and the Duke of Edinburgh in October 1955. He is the author of the book, "The Art of Scientific Investigation". Both on account of his outstanding reputation and his interest in international co-operation, he will be a most welcome president of the newly founded World Veterinary Association.

Amendments to the U S Atomic Energy Act

In a report by the United States Atomic Energy Commission (The Indemnification of Atomic Energy Activities and Operations of Advisory Committee on Reactor Safeguards, 1958–59. Report of the Joint Committee on Atomic Energy on Operations under Section 170 of the Atomic Energy Act of 1954 as Amended. Pp iii + 74. Washington, D C: United

States Atomic Energy Commission, 1959), details are given of the proposed regulations approving the form of nuclear energy liability insurance policies and Commission indemnity agreements Amendments to the indemnity proposals of the Atomic Energy Act, 1954, which it is proposed to submit to Congress, exclude liability for damage to property located at the site of, or used in connexion with, the licensed activity, and would authorize the Commission to fill a gap for a sufficient period of time in which to give the licensee reasonable opportunity to furnish the required protection The Commission is also studying the possible gaps resulting from the 'common occurrence' provision, and has entered into a contract for a study of criticality hazards as part of its continuing study of the problem of extending indemnity to materials licensees As regards foreign liability problems, the efforts of the Commission have been directed primarily to encouragement and support of the efforts of other governments to enact their own legislation and effect international arrangements

Scientific Staff in New Zealand

DURING the past twelve months, six officers of the Ruakura Animal Research Station in New Zealand have resigned to accept posts in Australia All have received an increase of salary of £A500 to £A1,000 on taking up their new posts The maxima attached to their new position in Australia is, in all cases, about twice that offered for the positions they vacated in New Zealand Another 25 individuals have resigned from Government laboratories or science departments of New Zealand universities during the past three years to accept overseas posts, mainly in Australia This figure does not include graduates in science who have gone overseas for advanced training

Both Government departments and the universities experience great difficulty in replacing the losses of scientific staff with persons of the desired quality The Soil Bureau of the Department of Scientific and Industrial Research has been seeking pedologists for some time without success, and advertisements for mycologists, entomologists, mathematicians and physiologists have failed to attract any applicants or applicants of the desired qualifications and calibre Whereas five years ago there were usually a number of highly qualified applicants for each vacancy from which selection could be made, the position has changed so that to-day only one or two such applicants and sometimes none at all apply for advertised positions

Scientific Research in British Universities

"SCIENTIFIC Research in British Universities, 1958–59", based, as in previous years, on material collected by the British Council from heads of departments of the universities, who are alone responsible for the entries, now runs to 446 pages (pp xii+446 London H M Stationery Office, 1959 25*s* net) These brief notes on scientific research in progress during the 1958–59 session indicate the nature of the projects in sufficient detail to show the scope of the research Entries are arranged in alphabetical order of university or university college, and under each institution the arrangement is alphabetically by subject The head of the department is named, with those permanent members of staff actually engaged in supervising research There are alphabetical name and subject indexes

Registration of Scientific and Technical Persons, 1958

FRESH and renewed registrations for all professional classes covered by the Technical and Scientific Register of the Ministry of Labour, with the exception of mathematicians and physicists, steadily increased during 1958, according to the Ministry's annual report At the end of December, registrations, including those seeking a change as well as those employed, were 29 per cent higher than in December 1957, a significant part of the increase comprising registrations of men in the middle age groups seeking better positions before age restricted their prospects and from ex-regular members of the Forces who had retired or anticipated premature retirement At December 8, 1958, of 4,556 on the register, compared with 3,538 in 1957, 1,326 were unemployed Premature retirements from the Services reached a peak during the year, but the Regular Forces Resettlement Service, set up by the Ministry, received encouraging support from industry and commerce, and there was no significant increase at the end of the year in the number of such applicants unemployed The report also directs attention to the establishment in July 1958 by the British Employers' Confederation, the Trades Union Congress and the boards of the nationalized industries, of the Industrial Training Council in accordance with the recommendation of the Carr Committee This Council has undertaken as its first task the encouragement of industry generally to take advantage of the opportunities provided by the 'bulge' of school-leavers to expand apprenticeship schemes and other forms of training Thirty-two appointments were made to the general factory inspectorate, and with five applicants awaiting appointment, the number of vacancies at the end of the year was nine Five additional appointments were made to the Engineering and Chemical Branches of the inspectorate On the advice of the National Advisory Committee on the Employment of Older Men and Women, the Ministry is discussing with the Department of Scientific and Industrial Research and the Medical Research Council arrangements to ensure co-operation between the Ministry, industry and research organizations and to stimulate research into problems of employment of older workers

Rubber Research

THE twenty-second "Annual Report on the Progress of Rubber Technology" covers the progress of rubber technology during the year 1958 (edited by Dr T J Drakeley Pp ix+125+xii Cambridge W Heffer and Sons, Ltd , 1959 Published for the Institution of the Rubber Industry) The report contains twenty-three sections, by different contributors, covering all aspects of the technology of rubber-like materials, both natural and synthetic, ranging from surgical goods to the use of rubber in roads The report also includes sections on historical and economic aspects, planting and production of natural rubber, fibres and fabrics used in conjunction with rubber, compounding ingredients and, for the first time, a separate section on the manufacture of synthetic rubbers The introduction of this latter section is timely since 1958 saw the opening in Italy, Germany and the United Kingdom of the first major European plants for the production of general-purpose synthetic rubber Synthetic elastomers are now firmly established as a large and important part of the rubber industry Already approximately 65 per cent of American new-rubber consumption consists of synthetics; the corresponding figure for the rest of the world (excluding Communist countries) is 25 per cent, but this is likely to increase with the opening of the new plants. The year does not appear to have produced any outstanding new technical developments but rather a steady improvement of materials and techniques. The report contains more than one thousand references to scientific and technical publications, although, as is inevitable in a work of this kind, there is some overlapping from section to section.

Aerial Photographic Exhibition of Quarries and Mines

A SPECIAL exhibition of aerial photographs of quarries and mines opened at the Geological Museum, Exhibition Road, London, S.W.7, on October 15. Admission is free. The exhibition will remain open for several months. The photographs show past and present surface aspects and effects of quarrying and mining in the United Kingdom, and illustrate the great variety of useful rocks and minerals found in Britain. All the photographs are from the Cambridge University Collection, an extensive library of air photographs specially selected to meet needs of teaching and research. They have been taken during recent years by Dr. J. K. S. St. Joseph, curator in aerial photography at Cambridge, from aircraft of the Royal Air Force on training flights.

Petroleum Industry in Great Britain

THE Petroleum Information Bureau has published under the title "U.K. Petroleum Industry Statistics relating to Consumption and Refinery Production, 1957 and 1958" (Pp. 10. London: Petroleum Information Bureau, 1959) figures covering all petroleum products, whether imported or from indigenous sources, as well as substitutes such as benzole and hydrogenated spirits. Refinery production figures do not count further treatment of finished products for special grades. The figures relate to 1957 and 1958, in which deliveries and consumption of petroleum products totalled 24,784,586 tons and 31,065,629 tons, respectively.

New Journal of Glass Technology

MORE and more problems in the physics and chemistry of glasses are being investigated in laboratories all over the world. At present the results are published in many non-specialized journals and the time has come to provide a vehicle for these papers. The Society of Glass Technology has therefore decided that from February 1960 its *Journal* should be published in two parts. These will be called *Glass Technology* and *Physics and Chemistry of Glasses*. Both journals will contain papers, abstracts, communications to the editor and book reviews. Arrangements are being made with the Abstracting Board of the International Council of Scientific Unions to ensure that papers published in these new journals will be abstracted as widely as possible and also that the abstract sections will be comprehensive. *Glass Technology* will contain reports of applied science in the glass industry, and subjects considered suitable include: control of batch compositions; corrosion of refractories; design, operation and performance of furnaces; methods of chemical and physical testing; melting processes; statistical analysis of industrial experimentation. In *Physics and Chemistry of Glasses* will be published reports of original studies of the physics and chemistry of glasses, both experimental and theoretical. Possible subjects include: electrical properties; infra-red absorption; relaxation processes; thermodynamics of the glassy state; viscosity; X-ray diffraction. Copies of the Society's notes for authors are available from Prof. R. W. Douglas, Society of Glass Technology, Thornton, Hallam Gate Road, Sheffield 10.

Plant Nematology

IT is now recognized that eelworm diseases are among the most important problems in plant health and there has been a rapid increase in the study of plant parasitic nematodes in all countries where the growing of plants has become an organized industry. Unfortunately, there is a shortage of trained specialists in nematology and of introductory literature on the subject. The Ministry of Agriculture's new Technical Bulletin No. 7 (Pp. vii+175+12 plates. London: H.M. Stationery Office, 1959. 9*s*. 6*d*. net) provides a general introduction and is based on the lectures given at a special training course held at the National Agricultural Advisory Service regional headquarters, Bristol, in 1956. It also reviews the more important nematode problems in British agriculture and is in part designed as a companion volume to Technical Bulletin No. 2 (Laboratory Methods for Work with Plant and Soil Nematodes). Although primarily designed for nematologists it should also be of interest to agricultural entomologists, plant pathologists and others who have to advise on eelworm problems and also to students and teachers of zoology, agriculture and parasitology. It contains 21 articles by research and advisory workers, arranged in six main sections covering the general structure and classification of nematodes, the more important genera, several practical and research problems with cyst-forming eelworms, control and cultural studies.

Sea Fisheries Research in East Africa

THE annual report for 1958 of the East African Marine Fisheries Research Organization (pp. 20. Nairobi: Government Printer, 1959. 4*s*.) is one that reflects great credit on the small staff at Zanzibar. Research on the fish and fish-stocks of the Indian Ocean, first at Mauritius and now at Zanzibar, has been the post-war concern of the director, Dr. R. H. Wheeler, and it is good to learn from him that the phase during which it has been of first necessity to identify species is passing. In spite of the need to do systematic work, Dr. Wheeler, operating from Mauritius with a small converted fishing vessel, had already discovered a large and potentially rewarding line fishery in the neighbourhood of Seychelles Banks. The same vessel was transferred to Zanzibar, but during 1957 it was replaced by a large and more serviceable trawler, the *Manihine*. Among other tasks assigned to *Manihine* was floating long-line fishing for yellow-fin tuna and striped marlin. Using seven miles of line and two hundred and fifty hooks on or below the thermocline at 50–70 fathoms, heavy catches were made. These results are most encouraging for all those who wish to see the Colonies, Dependencies and emerging Commonwealth countries of Africa break into the oceanic resources of pelagic fish now so largely in the hands of the Japanese.

Translocation of Amino-Acids

THE translocation of carbon-14-labelled amino-acids and amides in the stems of young soyabean plants has been investigated by C D Nelson and P R Gorham (*Canadian J Bot*, 37, 3, 431 (1959)) with the following results In all, the translocation of each of seven amino-acids and three amides was measured for periods of 5 minutes or less after introduction through the cut petiole of a primary leaf The compounds used were asparagine, urea, glutamic acid, glutamine, glycine, norleucine, arginine, serine, alanine and aspartic acid During the short times of these experiments it was found that each compound was translocated downwards as such The amount of carbon-14 in the stem decreased logarithmically from the point of introduction Each compound was translocated with unchanged velocity past a short section of stem killed with steam There was no translocation of aspartic acid through a stem that had an entire internode killed with steam Potassium cyanide (10^{-2} *M*) did not inhibit the velocity of translocation of any of the compounds although the logarithmic pattern of distribution of arginine was altered The minimum velocity of translocation was different for each compound and varied between 350 cm per hr for asparagine and 1400 cm per hr for aspartic acid The authors have also reported on the physiological control of the distribution of these substances (*Canadian J Bot*, 37, 3, 439 (1959)) From the point of introduction, translocation of each amino-acid or amide was mainly downward towards the root, very little was translocated upward Both excision of the roots and chilling decreased the velocity of downward translocation of aspartic acid, indicating that the roots exert a strong 'demand' which favours translocation in a downward direction more than an upward direction in the stem

Volcanic Activity on the Moon

In a brief article, N A Kozyrev (*Priroda*, 3, 84, 1959) describes his observations of the Moon since 1955 and provides a critical examination of the records of the Alphonse crater on November 3, 1958 In his opinion the spectrographic evidence suggests strongly that an eruption of volcanic ash did take place on that date on the Moon This eruption was followed by the emission of gases containing C_2 molecules

Astronomische Gesellschaft Star Catalogues

Between 1868 and 1908 the Astronomische Gesellschaft organized the production of a catalogue of all the stars brighter than the ninth magnitude in the northern sky A dozen observatories shared in this work, the observations being made visually using meridian circles It was later decided to repeat the whole programme photographically, and new observations were obtained during the years 1928–32 The Hamburg Observatory photographed the sky north of +20° declination, the Bonn Observatory that from +20° to −2° Observations of 14,000 reference stars were made at several observatories The measurement of the photographs and the reduction of the measures have been in progress since 1932, and publication of the results began in 1951 The results are contained in a fifteen-volume catalogue, and the last five volumes of this catalogue have recently been published The catalogue contains the positions of 180,000 stars down to magnitude 11 5 No proper motions for the stars were deduced because it was impossible to free the earlier catalogues from systematic errors The homogeneity of the results of this large undertaking represents one of its most important features, and the catalogue is, and will remain, a landmark in positional astronomy The catalogue is known as the *AGK*2

It has been decided to repeat the whole catalogue with a mean epoch of about 1960 18,000 secondary reference stars are being observed at various observatories, the photography is being performed at Hamburg and 1,939 plates will be required It is hoped to have positions and proper motions for all the 180,000 stars by 1965 This new catalogue, the *AGK*3, will enable astronomers to determine the systematic errors of old catalogues, connect the proper motions of the bright stars with those of fainter stars measured relative to the extragalactic nebulæ, and provide much data for geodetic purposes

Courses in Chemical Engineering

A new pamphlet, "Scheme for a Full-time Course in Chemical Engineering" (pp 16 London Institution of Chemical Engineers, 1959 2*s*), is a revised version of the "Scheme for a Degree Course in Chemical Engineering", originally issued in 1944, and takes account of current developments in teaching chemical engineering at technical colleges The course covers three years, and although in the first two years most of the time is spent on physical, organic and inorganic chemistry, the physics of solids, electricity, and mathematics, fluid mechanics, heat and mass transfer, the design and construction of process plant, power thermodynamics and engineering drawing are introduced at this stage and not left until the final year In this year the course comprises fluid and particle mechanics, heat and mass transfer, separation processes, applied chemical thermodynamics and kinetics, fuels and combustion and design problems Practical experience in works is regarded as an essential adjunct to the course, and the economic aspect should be introduced into lectures on chemical process principles in the first year The course should not be so rigid as to preclude transfer to chemical engineering in the earlier years by students who have commenced studies in a cognate faculty

Talanta Medal

The board of editors of *Talanta* announces a new award to be known as the Talanta Medal The publishers, Pergamon Press, are providing the funds for this Medal, which will have a value of 100 guineas and which will be awarded for outstanding contributions to analytical chemistry The Medal will not normally be awarded more frequently than once a year, but no attempt will be made to award it at any stated intervals This award will be either to analytical chemists who are responsible for major developments in the subject or to scientists whose work is judged to have contributed in a substantial way to the developments in the field of analytical chemistry Applications should be sent to the editors of *Talanta*, c/o Pergamon Press, 4–5 Fitzroy Square, London, W 1

Perkin Centenary Trust

The programme of awards for the year 1960–61 will include one Perkin Centenary Fellowship, valued at not less than £600 a year, which is available to a graduate for advanced studies, and two Perkin Centenary Scholarships at £300 a year, which are intended to give young persons employed in the industries concerned with the manufacture or the application of colouring matters the opportunity of full-time education at a university or technical college Applications are invited for the Perkin Trust Travel Grants from teachers concerned in the study of any aspects of the manufacture or applications of colouring matters at a university or technical college or other institute The purpose of the grants is to enable teachers to make short visits to comparable institutions overseas to widen their experience The secretary to the trustees is Dr J R Ruck Keene, to whom inquiries relating to awards should be addressed, at the Chemical Society, Burlington House, London, W 1

Harkness Fellowships of the Commonwealth Fund

THE awards bearing since 1925 the title Commonwealth Fund Fellowships were renamed in 1959 the Harkness Fellowships of the Commonwealth Fund All Fellowships are tenable in the United States and are offered, in separate series, to candidates from the United Kingdom, Australia and New Zealand, and Western Europe The Fund, an American philanthropic foundation, believes that international understanding may be promoted by opportunities for education and travel in the United States Thirty Fellowships are offered in 1960 to candidates from the United Kingdom who are British subjects and are either graduates or have experience in government service, the professions, the creative arts, journalism, branches of business or industry Forms of application, which must be returned before December 1, can be obtained from the Warden, Harkness House, 38 Upper Brook Street, London, W 1, from whom further details can be obtained

British Institution of Radio Engineers Awards

THE Council of the British Institution of Radio Engineers has announced the award of a number of premiums for outstanding papers published in the Institution's *Journal* during 1958 the senior award, the Clerk Maxwell Premium, goes to Mr C Powell and Mr D A Hendley (Decca Navigator Co , Ltd) for the paper, "Dectra A Long Range Radio Navigation Aid" , Heinrich Hertz Premium to Mr K Foster (Cossor Radar and Electronics, Ltd) for the paper, "The Characteristic Impedance and Phase Velocity of High-*Q* Triplate Line" , for the third successive year the Sir Louis Sterling Premium to Dr A van Weel (Philips, Eindhoven) for his paper, "Design of Detector Stages for Signals with Symmetrical or Asymmetrical Side-bands" , Sir J C Bose Premium to Dr B Ramachandra Rao, Dr M Srirama Rao and Mr C Abhirama Reddy, from Andhra University, South India, for their paper entitled "Magneto-ionic Fading in Pulsed Radio Waves reflected at Vertical Incidence from the Ionosphere" , Brabazon Premium to Prof D G Tucker, Dr V G Welsby, Mr R Kendall and Mr D E N Davies for their associated papers entitled "Electronic Sector Scanning" and "Radar Systems with Electronic Sector Scanning" , and Marconi Premium to Dr Morton B Prince and Mr M Wolf, of Hoffman Electronics, Inc , Evanston, Illinois, U S A , for their paper "New Developments in Silicon Photo-voltaic Devices"

Volume Fifty of the "Large Soviet Encyclopædia" ("Bolshaya Sovietskaya Enziclopediya")

THIS volume, part of a set of fifty, could not be sold separately when it was originally issued In 957, however, a special edition of 300,000 copies was printed, which could be sold separately Thus this finely printed and bound volume of 764 pages can be purchased in Britain for the sum of £2 It contains summary articles or reviews of all aspects of the Soviet Union and thus it is an invaluable reference book for anyone interested in this subject It is illustrated by a large number of folding and text maps, plates, text figures and tables Scientific workers will be interested in the following chapters 3, geography, geology, climate, soils, vegetable and animal worlds of the Soviet Union , 4, population , 5, history , 9, economics , 12, education , 15, science Chapters which follow deal with literature, arts and other subjects Chronological tables and a name index are placed at the end

Announcements

DR A J P MARTIN, of Elstree, Herts, Dr R L M Synge, of the Rowett Research Institute, Bucksburn, Aberdeenshire, and Dr A T James, of the National Institute for Medical Research, Mill Hill, have been awarded John Price Wetherill medals of the Franklin Institute for their development of gas–liquid (partition) chromatography

AT the sixth annual general meeting of the Association of Clinical Biochemists, held at the Royal College of Surgeons, London, on October 3, the following officers were elected *President*, Dr C P Stewart , *Chairman*, Dr A L Latner , *Hon Treasurer*, Dr J H Wilkinson , *Hon Secretary*, Dr A L Tárnoky, Royal Berkshire Hospital, Reading

A REGIONAL training course for laboratory technicians sponsored jointly by the University Institute of Chemistry, Lahore, and the Unesco South Asia Science Co-operation Office will be held at the University Institute of Chemistry, Lahore, Pakistan, during November 23–December 19 Inquiries should be addressed to the Unesco South Asia Science Co-operation Office, 21 Curzon Road, New Delhi, India

IN a written answer in the House of Commons on July 30, the Chancellor of the Exchequer stated that, to assist the Government in making a review of the control of public expenditure, he was appointing a small group to make a full examination of the whole problem, in consultation with all major departments, and to formulate proposals Lord Plowden would take general charge of this work, and besides senior officials from departments, including the Treasury, the group would include two or three persons from outside the Government service

THE Chemical Society has announced that applications for Research Fund grants should be submitted not later than November 14 Further information can be obtained from the General Secretary, Chemical Society, Burlington House, London, W 1

THE Institute of Physics is organizing a conference during November 13–14 on "Structure Analysis and Experimental Techniques" The conference is to be held at the Institution of Civil Engineers, Great George Street, London, S W 1 Further information can be obtained from Dr P T Davies, "Shell" Research, Ltd , Thornton Research Centre, P O Box 1, Chester

ERRATUM In the communication entitled "Prevention of the Onset of Seed Dormancy by Gibberellic Acid", by Dr M Black and J M Naylor, in *Nature* of August 8, p 468, in the legend to Fig 1, for "2 replicates each comprising 50 embryos" read " 2 replicates each comprising 50 caryopses"

SCIENTISTS IN THE PUBLIC SERVICE IN BRITAIN

SPECIAL PROMOTIONS

FURTHER posts have been created in the Civil Service as in previous years under provisions included in the White Paper on the Scientific Civil Service (Cmd. 6679, 1945) to provide for the promotion of individual research workers of exceptional merit. The promotions were effective from July 1, and include the following.

Deputy Chief Scientific Officer

Dr. J. S. Hey joined the Army Operational Research Group in 1940, becoming its head in 1949. In 1952 he formed a research section of what is now the Royal Radar Establishment. Both before and since going to Malvern, he made exceptionally distinguished pioneering contributions to radio astronomy which were the basis for his D.Sc. His work for the Ministry of Supply has also included important contributions on the mechanism of electromagnetic scattering and the ionization associated with discontinuities in hypersonic gas flows, all marked by originality and simple elegance in experimental technique. He is a Fellow of the Physical Society and the Royal Astronomical Society, has served on the Council of the latter and was this year awarded the Eddington Medal. He serves on Commissions of the International Astronomical Union.

Dr. H. G. Hopkins was at the Royal Aircraft Establishment during the war years, working primarily on the theory of elastic stability and of stress distribution in aircraft structure. In 1946 he returned to academic teaching and research. He joined the Armaments Research Development Establishment in 1954 and has been concerned with damage to structures, camouflet and crater formation in soils and dynamic studies in metal plasticity.

Mr. D. H. Sadler is superintendent of H.M. Nautical Almanac Office, the work of which is divided between the highest theoretical and numerical requirements of fundamental astronomy and celestial mechanics and the practical requirements of astronomical navigation. It was largely due to him that the Royal Air Force had such excellent almanacs and tables during the Second World War. Since then the provision for astronomical navigation, both at sea and in the air, has been much expanded and is now completely unified with that in the United States. Mr. Sadler has contributed much to the theoretical side of navigation and has been awarded the premier awards of both the British (Gold Medal, 1957) and the American (Thurlow Award, 1948) Institutes of Navigation; he was president of the British Institute during the period 1955–56. He is at present general secretary of the International Astronomical Union, and he was secretary of the Royal Astronomical Society during 1939–47. During the Second World War he also directed the computational side of the highly successful Admiralty Computing Service.

Senior Principal Scientific Officer

Mr. J. M. Craddock is serving in the assistant directorate of Dynamical Research in the Meteorological Office of the Air Ministry and is engaged on research into the problem of long-range weather forecasting.

Mr. F. J. Bradshaw, of the Metallurgy Department, Royal Aircraft Establishment, is a fertile research worker on the physics of metals.

Mr. A. G. Earl, of the Guided Weapons Department, Royal Aircraft Establishment, is a research engineer who has studied the fuel system and control systems of guided missiles.

Dr. H. Kolsky, of the Armament Research and Development Establishment, after a distinguished outside career devoted mainly to the mechanics of solids, has recently joined Dr. Hopkins at Fort Halstead.

Dr. E. H. Mansfield, of the Structures Department, Royal Aircraft Establishment, has studied mathematical aspects of aircraft structural research, most recently in connexion with the effects of kinetic heating.

Dr. A. H. Cook (National Physical Laboratory, Standards Division) is primarily engaged in the accurate measurement in absolute terms of certain physical quantities and constants.

Mr. C. G. Giles (Road Research Laboratory) has conducted research aimed at finding ways of reducing the number of road accidents due to skidding.

Dr. A. C. Hulme (Ditton Laboratory of the Food Investigation Board, now of the Agricultural Research Council) works on various aspects of the biochemistry and physiology of apples and other fruits, especially on biochemical changes in respiration during storage.

Mr. A. Silverleaf (National Physical Laboratory, Ship Division) is in charge of the group responsible for research and design in the fields of ship propulsion, cavitation and vibration.

Dr. E. H. Rhoderick joined the Services Electronics Research Laboratory in 1955 and is working at present on very fast switching for computers using superconductors.

Mr. S. B. Kendrick, of the Naval Construction Research Establishment, is an authority on the design of submarine pressure hulls.

Similar promotions have been made by:

(1) U.K. Atomic Energy Authority

Deputy Chief Scientific Officer

Dr. G. E. Bacon spent the war years at the Telecommunications Research Establishment on the development of ground radar equipment, particularly aerial systems. In 1946 he joined the Atomic Energy Research Establishment at Harwell, where he has worked on the application of X-ray and neutron diffraction to the study of the solid state. He is known especially for his work on the structural crystallography of graphite and for neutron studies of hydrogen bonds and thermal motion in hydrated and organic substances.

Dr W B Thompson took up a Harwell Senior Fellowship in 1950 and is now the senior theoretical physicist working on the problems of fusion reactors His section of the Theoretical Physics Division carries out mathematical investigation into the stability of high-current gas discharges, on the rates of loss of heat from gases at temperatures of more than a million degrees centigrade, and on the effects of magnetic fields on the bulk and particle motions of highly ionized plasmas The work includes interpretation of the many fundamental experiments in this field carried on in all parts of the world and assessment of its significance to the building of a theory good enough to allow final success in the fusion reactor field

Mr W Walkinshaw is one of Britain's leading particle accelerator theoreticians, joining the Telecommunications Research Establishment in 1940 where he carried out theoretical research on radar and on high-energy particle accelerators He has worked at the Atomic Energy Research Establishment, Harwell, since 1951 His section of the Theoretical Physics Division is very closely associated with the Rutherford Laboratory of the new National Institute for Nuclear Research, and has been engaged principally on the large 7,000 MeV proton synchrotron which is still under construction In addition to this continuing task, the group is charged with the duty of conceiving new types of accelerating machines and specifying designs for other machines of tested types

Senior Principal Scientific Officer

Dr K W Bagnall is at Harwell in charge of a section of the Radiochemistry Branch of the Chemistry Division which is concerned with research into the chemistry of the actinide and other heavy elements At present, the main interest is in protactinium

Dr A M Lane is part of the team of theoreticians whose task it is to ensure that the Atomic Energy Authority is fully armed with the most up-to-date and reliable knowledge of nuclear physics

(2) Agricultural Research Council
Deputy Chief Scientific Officer

Dr R L Mitchell joined the staff of the Macaulay Institute for Soil Research, Aberdeen, in 1937 He is deputy director of the Institute and head of the Department of Spectrochemistry Dr Mitchell has been responsible for the development of spectrochemical methods applicable to the analysis of soils, plants and related materials, involving the evolution of techniques and equipment for arc, spark and flame emission methods The chemical concentration technique is now quite widely used throughout the world and many overseas workers have visited the Macaulay Institute to study the spectrochemical methods developed by Dr Mitchell and his co-workers More than sixty publications describe methods employed and the valuable results obtained in the study of trace element relationships in soils and plants and of the geochemical background to their occurrence The work of his department also includes the use of infra-red and ultra-violet absorption methods for the examination of organic and inorganic soil constituents

Senior Principal Scientific Officers

Dr N J Berridge is a member of the staff of the National Institute for Research in Dairying and is well known as an authority on rennin

Dr Alan Robertson, of the Agricultural Research Unit of Animal Genetics, Edinburgh, is widely recognized as one of the most successful students of the rapidly expanding subject of population genetics

Dr V P Whittaker, of the Agricultural Research Institute of Animal Physiology, Babraham, Cambridge, has done outstanding research in the cholinesterase field

(3) Development Commission
Senior Principal Scientific Officer

Dr J W G Lund is in charge of the Freshwater Biological Association and has made important contributions to the understanding of the factors which, by controlling the annual phytoplankton cycle, determine the fertility of lakes and reservoirs

(4) Nature Conservancy ·
Senior Principal Scientific Officer

Mr J G Skellam is head of the Biometrics Branch of the Nature Conservancy, contributing to mathematical biology, and in particular to theoretical study of population dynamics and statistical ecology

CONCEPTION OF EVOLUTION

MEETING IN PARIS

The Muséum National d'Histoire Naturelle celebrated on June 5 the anniversaries of the "Precurseurs et Fondateurs de l'évolutionnisme—Buffon, Lamarck, Darwin" the 250th anniversary of Buffon's birth, the 150th anniversary of the publication of Lamarck's "Philosophie zoologique", and the centenary of Darwin's "Origin of Species". The meeting was held in the famous Grand Amphitheatre, planned during Buffon's administration, and which, reconditioned about four years ago, is again used for its original purpose A large and distinguished audience including many famous scientists, some of whom have long been retired, was present

Prof Roger Heim, director of the Museum, gave an opening discourse, first summarizing the pre-Buffon period with his customary clarity and grasp of essentials If in this he appeared to stress the views of naturalists of the old Jardin du Roi it was inevitable, for naturalist-philosophers were almost confined to France at the time—and to the Garden There were clear statements about transformism before Buffon, and equally there was a belief in the fixity of species after him An upholder of this was Bosc, one of the founders of the Linnean Society of Paris in 1788, the same year as that of London was started One of the first acts of the society was to petition for the erection of monuments in the Garden to the memory of famous scientists, beginning with that of Linnæus, later destroyed by *sans-culottes*.

Prof. Jean Piveteau, of the Sorbonne, a well-known authority on Buffon, gave an account of his personality with particular reference to his ideas on evolution, how they developed and how, at times, they seemed incompatible. A valuable commentary gave the reasons for this, both psychological and diplomatic. Few men are so misjudged in Great Britain as Buffon. He had an enormous influence on the thought of his time. He was a man of wide scientific attainments and in every way a man of the world. His Discourse on Style, delivered on his admittance to the Academy of Sciences in August 1753, has given him his place in literature. This celebrated discourse was read at the meeting by M. Toni Taffin of the Comédie-Française. The audience was obviously thrilled to hear the sonorous phrases which probably all had read—there were at least sixty editions of it in the nineteenth century.

Dr. J. Ramsbottom followed with an account of the lives and work of Jean Lamarck and Charles Darwin. Lamarck first postulated progressive evolution; Darwin put the doctrine of evolution on so sound a basis that it became generally accepted. It was a pleasing acknowledgment of Darwin's epoch-making "Origin of Species" that he should be given a prominent place in what was essentially a celebration of French achievements; moreover, it was logical in realizing that it was the book and not the preliminary announcement of natural selection which was important. So Lamarck and Darwin could be spoken of as searchers after truth without some of the nonsense which has been allowed to belittle the former. Comparing the basic ideas of the two—Lamarck held that an organism in a changing environment is stimulated to vary; Darwin that variation is independent of the environment. For both the environment—adaphic, physical and biotic factors, the last including competition, parasitism, etc.—is all-important. Natural selection is not active like artificial selection, but passive: an organism can live under certain conditions, or it cannot. Lamarck suggested that the simpler animals and plants would provide instructive facts. Evidence accumulated since the introduction of pure culture methods suggests that environmental conditions can produce definite inheritable changes, though not necessarily of the kind Lamarck propounded. The boosting up of penicillin production in *Penicillium chrysogenum* has much in common with what Darwin considered to be the effects of domestication.

Mme. G. Duprat, librarian to the Museum, then gave an account of the career of P. J. Redouté, born in 1759, who was artist to the Garden and painted many of the famous *vélins*. She showed a series of projections of portraits of Redouté and a large number of his paintings, several of which were of specimens from the Royal Botanic Garden at Kew. An exhibition was arranged in the corridor adjoining the amphitheatre showing many of Redouté's original paintings and a number of his published plates; also an announcement of his lectures. The Muséum d'Histoire Naturelle, as one of its main functions, acts as a teaching university. There are at present 24 professors who give courses of lectures covering a very wide field, but there are no degrees awarded as the result of examinations. The system is *sui generis*.

Prof. H. V. Vallois, director of the Musée de l'Homme—attached to the Natural History Museum—gave a history of the Société d'Anthropologie, founded in 1857. In spite of the date the Society's beginning was in no way connected with the publication of the "Origin of Species"; indeed, it preceded it by six months. Social and physical anthropology in the widest sense have been the scope of the Society, and its activities, as outlined, make an impressive history. It is noteworthy how Darwin's name became increasingly prominent after the publication of his "Descent of Man" in 1871. Cuvier, the great exponent of catastrophism, died in 1832, but though there was no successor to stamp out heresies his influence was such that Lamarck's beliefs were still discredited and it was not until Darwin amassed and arranged the evidence that inquiries about the status of fossil man became scientifically respectable.

The last paper, by M. Franck Bourdier, assistant chief of the Service de Muséologie, dealt with the French forerunners of evolution. They make an imposing list far outnumbering the combined total from all other countries. The notion of permanent change in organisms and that of evolutionary sequence stood out clearly. It would be useful to distinguish between them, possibly by speaking of the first as transformism and the second as evolution.

In an adjoining corridor an exhibit was arranged where the matter of this lecture could be studied at leisure and in greater detail. Here again Darwin was included as the end of the old period or as the beginning of the new.

In addition to this intellectual feast and as part of the anniversaries, an excellent exhibition was staged in the gallery of the Botanical Museum, dealing with the history of the doctrine of evolution and illustrating development up to and including man. Specimens, casts, models, photographs and all the modern methods of display provided a most instructive and convincing story.

J. Ramsbottom

X-RAY MICROSCOPY AND X-RAY MICROANALYSIS

THE second International Symposium on X-ray Microscopy and X-ray Microanalysis was an independent meeting held in Stockholm in 1959, and sponsored by the same three laboratories as were responsible for arranging the first Symposium, held in Cambridge in 1956: the Department of Medical Physics, Karolinska Institutet, Stockholm; the Departments of Physics and Biophysics, Stanford University, California; and the Electron Microscope Section of the Cavendish Laboratory, Cambridge. The attendance of 180 was 50 per cent greater than that at the previous meeting, although the number of papers presented (74) was not appreciably greater than before (66). The participants were drawn from seventeen different countries and from 120 different laboratories.

The programme was divided according to the nature of the physical techniques employed. X-ray absorption microradiography, X-ray emission microanalysis, and X-ray microdiffraction analysis Each division was sub-divided into sections on methodological aspects and equipment, technical applications and biological applications The number of communications under these three cross-divisions was 43, 10 and 21, respectively, showing that the development of techniques is still enjoying most attention and that their application in biology and medicine is ahead of that in mineralogy and metallurgy

In absorption microradiography, interest was mainly in the relative merits of the contact and projection techniques, only two contributions being concerned with the reflexion method, in which the correction of aberrations is still the main problem For qualitative microscopy, all three methods at present have about the same limit of resolving power, at about 0 25μ H H Pattee (Stanford University) has investigated a number of alternatives to the photographic emulsion for recording the X-ray image in contact microradiography, including radiosensitive dyes and plastics, some of which give images which can be enlarged in the electron microscope J H Auld and J F McNeil (Aeronautical Research and Defence Standards Laboratories, Australia) showed that xerography with liquid developers allows a resolution comparable with that given by ultra-fine grained X-ray films and at exposure times similar to those of the fastest X-ray films In the projection method, improvements are being made in the technique of focusing at very high resolution (W C Nixon, Cavendish Laboratory) and in obtaining improved contrast (S P Ong and J B Le Poole, Delft) The main emphasis, however, was on the perfection of the absorption procedure for microanalysis, whether of particular elements (sulphur, phosphorus, calcium) or simply of the dry weight of biological tissues The contact method has been developed for this purpose, especially in Swedish laboratories, and improvements in the technique were described by Howling and Fitzgerald (New York), Hydén and Larsson (Gothenburg), Lindstrom and Hoh (Stockholm) and Muller and Sandritter (Frankfurt-on-Main) The accuracy of analysis varies between 5 and 10 per cent, depending on the nature of the specimen A detailed study of all the factors involved is being made by Henke (Pomona College, California), using red blood-cells as standard specimen In the projection method direct measurements can be made with a counter on the enlarged X-ray image, thus eliminating the stages of photography and microphotometry, so that the accuracy of analysis is better In determinations of calcium in bone, Long (Cavendish Laboratory, Cambridge) obtained 2–3 per cent accuracy The smallest area which can be analysed is a few microns in diameter in either method, the limit being set by the light spot in microphotometry and by the counter aperture in projection recording The ultimate mass sensitivity is of order 10^{-11}–10^{-12} gm , since sections thinner than 10μ cannot be used

The applications of absorption microradiography, by one or the other experimental technique, covered a wide range of subjects In the inorganic sciences, papers were concerned with mineral dressing, petrography and mineralogy , in biology and medicine, with bone (six papers), vascular systems (five papers), other animal tissues (four papers, including a wide survey by Saunders, of Dalhousie University), plant tissues (two papers) and foraminifera (one paper) Most of this work was qualitative, only Lindstrom (Stockholm) and Sissons (Institute of Orthopædics, London) describing quantitative applications

X-ray emission microanalysis is more definitely a quantitative method, and rapid progress is being made with its development now that its value in metallurgy and mineralogy has been demonstrated In biological research, where compounds rather than elements are of interest, its scope is much more restricted The mechanism of emission is more complicated than that of absorption and in practice results are subject to a variety of corrections The efficiency of X-ray production by direct electron excitation was discussed by Archard (Associated Electrical Industries Research Laboratory, Aldermaston) and by Cosslett (Cavendish Laboratory, Cambridge), and the corrections for absorption and fluorescence by Philibert (Institut de Recherches de la Sidérurgie, Paris) and by Austin, Richard and Schwartz (Battelle Institute, Columbus) The factors limiting the spatial resolution (or 'localization') of the method were discussed by Duncumb (Cavendish Laboratory, Cambridge), the main factor being the very rapid decrease in electron-beam current as the focal spot is reduced to less than 1μ in diameter At present the practical limit is about 0 25μ, and further improvement must wait upon developments of the electron source, electron lenses and recording system A great gain is attainable if a proportional counter can be used for wave-length discrimination, instead of a crystal spectrometer, and Dolby and Cosslett reported promising results with a counter of wide collection angle coupled to an electrical network which can separate the pulses produced by neighbouring elements in the periodic table

Improvements in the design of microanalysers were reported from the laboratories of Associated Electrical Industries (Aldermaston) and Tube Investments (Hinxton) and from the Cavendish Laboratory The Associated Electrical Industries instrument is now being manufactured by Metropolitan-Vickers and the first model was on view during the meeting The production of the scanning microanalyser developed in the Cavendish and Tube Investments laboratories, which displays images of the distribution of selected elements in the specimen, was announced by the Cambridge Instrument Company The original static spot instrument of Castaing is in production in France, and two similar instruments are now being commercially made in the United States This activity has been stimulated by the great interest now shown in the method by metallurgists and mineralogists, which was reflected in the papers on applications by Austin, Long, Melford (Tube Investments) and Philibert All elements with atomic number greater than 11 (sodium) can already be analysed, with an accuracy in favourable cases of better than 0 1 per cent Since the localization of the analysis can be smaller than 1μ, in depth as well as in diameter, this corresponds to a minimum detectable mass of about 10^{-14} gm As the range of applications is extended, however, it is becoming clear that the limits of accuracy must be more closely investigated in each special type of alloy or mineral The work of Philibert on light alloys showed that very careful correction needs to be made for fluorescence effects as well as for absorption of X-rays from one constituent by the others present To reduce such corrections to a minimum, it will be desirable to build up a collection of reference standards so that one may be selected which is as close as possible in composition to the specimen under investigation. Comparison of the results obtained in three different laboratories, on the variation of nickel content across tænite inclusions in the same type of meteorite, indicated that standard methods of preparing the specimen must also be worked out. It was unfortunate that only an extended abstract was available of what would have been a most interesting paper by Borovski (Institute of Metallurgy, Moscow), who has independently developed the X-ray micro-analyser for metallurgical research. It appears that he has made great progress not only with standardizing the procedures, but also in the automatic recording of concentration curves. His main interest is in diffusion problems and in transfer processes between solid and liquid media.

In summary, it can be said that the emission microanalyser is leaving the stage of being an interesting piece of gadgetry and is now having to prove itself as a routine research tool, in the course of which its capabilities and limitations will become more clearly defined. In particular, it remains to be seen how far it can help in some of the main problems of ferrous metallurgy: exploratory determinations of carbon have already been made by Dolby, but what the limits of accuracy may be and whether carbon and nitrogen can be distinguished from each other are problems still to be solved.

The Symposium ended with two sessions on micro-diffraction, which becomes increasingly related technically to X-ray microscopical methods as the advantages of using micro-focus tubes are more widely appreciated. Further developments were described in the tubes themselves and in the spectrometers and micro-beam cameras used with them. The value of the method, especially in reducing exposure time to more practical limits when only very small crystals are available, emerged strongly from the work of Fournier (Centre National pour la Recherche Scientifique, Paris) on crystals from tumours, Mrs. Kennard (National Institute for Medical Research, London) on a number of clinical problems, Skertchly (Textile Physics Laboratory, Leeds) on keratinization of hair, and Wylie (Royal College of Technology, Glasgow) on the growth of crystals in balsa wood. Quite different techniques have been developed for investigating dislocations and other sub-structures in metals, by combining Bragg diffraction with X-ray microscopy. Extensions and applications of this 'Berg–Barrett' method were described by Newkirk (General Electric Laboratories, Schenectady) and Weissmann (Rutgers University, New Jersey). Shinoda and colleagues (Osaka University) had used a transmission variant of the method to investigate the recrystallization of zirconium and its alloys on the micro-scale.

A third symposium is planned for 1962, and will probably be held at Stanford University, California.

V. E. COSSLETT

THE BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

THE seventeenth meeting of the Research Panel of the British Gelatine and Glue Research Association was held on June 25, with Mr. S. G. Hudson (Richard Hodgson and Sons, Ltd.) in the chair. In the morning a review of certain aspects of the research of the Association was given by Mr. A. G. Ward, for whom it was the last meeting as director of research, and in the afternoon a discussion on gelation took place, with the main contribution from Mr. J. W. Janus (Kodak, Ltd.).

The review by Mr. Ward was entitled "The Present Position in Gelatine and Glue Research". The paper opened with a reference to a previous review given by the author to the second Research Panel meeting nine years earlier, in which considerable attention was given to those methods of polymer physics and chemistry which were applicable to the study of gelatin. The expansion of research on gelatin now made it necessary to limit the paper to the central problem of the structure of the molecules of the many different types of gelatin. This largely left on one side research on the collagen–gelatin conversion and also on gelation, except where these subjects threw light on the molecular structure of gelatin.

The chemical composition of gelatine, and animal glue, were shown to depend on the amino-acid composition of the gelatin itself, that is to say, of the collagen breakdown products, and on the occurrence and composition of rather small amounts of non-gelatin constituents. Separation procedures such as adsorption on activated charcoal, or '*IRC*50' resin, enabled small quantities of gelatin-free impurities to be obtained and analysed, and examination of fractions prepared with *iso*propyl alcohol showed that about 1 per cent of degraded protein, other than gelatin, might also be present in the residue from fractionation. Using hydroxyproline content as a measure of purity, it was suggested that a total of 3 per cent of organic impurities might be present, although the variation in hydroxyproline content could equally be the result of small differences in composition between gelatin molecules.

Revision of figures for the amide content of gelatines enabled very good agreement to be obtained between the analytical figures for the ionizable groups in gelatin and the results of titration curve determinations. This shows that, within experimental error, all the carboxyl, amino and guanidino groups are free to ionize and are not cross-linked. The accuracy attained did not make it possible to exclude the occurrence of a small number of cross-links involving these groups.

The properties of preparations of well-characterized soluble collagen extracted from calfskin, carp-swim bladder tunic and codskin, by Doty and co-workers, and their conversion of the soluble collagens to gelatin, could be explained in terms of dissociation of the triple-helix collagen structure. The gelatins obtained would, on this view, be single chains, free of cross-links. In contrast, first extract alkali process gelatins have been shown by Courts and Stainsby, using end-groups and light-scattering determinations of molecular weight, to be multichain, at least for the higher molecular weights. The relation between these results was discussed.

The problem of explaining the reduction in gel-forming ability in gelatine caused by neutral and alkaline degradation, although not by acid degradation, as distinct from any effect due to the reduction in molecular weight, still remained to be solved Suggested explanations were put forward in terms of internal re-arrangements of the protein chains which upset the ordered arrangement required for a gel bond, or alternatively, that intra-molecular cross-linking occurs progressively on heating under neutral or alkaline conditions, and interferes with subsequent gel formation

After a brief discussion Dr A Courts (British Gelatine and Glue Research Association) in moving a vote of thanks, expressed the appreciation of the staff of the help given to them by Mr Ward in his term of office Mr C F C Simeons (British Gelatine Works, Ltd), in seconding, added the thanks of the gelatine and glue industry

Mr Janus, in opening the discussion on gelation, gave a short paper on "The Formation and Structure of Gelatin Gels" He described the measured properties of gels, the rigidity of the matured gel, the melting-point and the setting time from the sol state, and showed how these depended on solution *p*H He emphasized that setting might occur in a short time even at room temperature, whereas the gel rigidity increased over long periods at 0° C The melting-point was, however, much less influenced by low-temperature maturing

The influence of guanidino content on setting time and melting-point was made clear, but not that on low-temperature rigidity Interference with setting can also be secured by alkaline copper solutions which are presumed to interact with the $\rangle$CO groups of the backbone An interaction between guanidinium groups and the backbone was therefore postulated as the mechanism of the early stage of setting To explain the continued growth of rigidity at low temperatures, reversion to the helical structure was suggested, and support was drawn from the optical rotation changes

Dr R Collison (British Baking Industries Research Association) presented a short paper by Dr G A H Elton and himself on "The Swelling of Starch" In this he described the swelling of the granules in water as the temperature is raised, and effects on the mechanical properties He also mentioned the action of surface active agents in controlling swelling, probably by forming a hydrophobic layer on the granules

Mr D D Carruthers (University of Durham) described measurements on gelatin gels at high frequency, and discussed the dependence on temperature of the mechanical properties

The general discussion was opened by Dr G Stainsby (British Gelatine and Glue Research Association), who emphasized the difficulty of establishing precisely the mechanism of gelation The vote of thanks to Mr Janus and the other speakers was moved by Mr E Bradbury (British Cotton Industry Research Association) and seconded by Dr A Jobling (British Glues and Chemicals, Ltd)

ALAN G WARD

THE TORRY RESEARCH STATION, ABERDEEN

THE Torry Research Station in Aberdeen of the Department of Scientific and Industrial Research, which was set up in 1929, together with its sub-station in Hull, the Humber Laboratory (opened in 1952), carries out research into the problems of fish preservation The occasion of the open days during June 15–17, when the Station was on show to scientists, equipment manufacturers, the fish industry and the general public, provided an opportunity both of seeing the range of practically the whole of the research in the United Kingdom into fish technology and also of assessing how the treatment of the fish we eat is likely to change in years to come

Although the fish industry has changed in numerous ways in the thirty years since Torry was opened, it nevertheless remains largely 'traditional', there are many small firms, mechanization to any substantial degree is found only in a few factories and, with the exception of deep freezing, the methods of preservation used were familiar to our grandparents Torry, which has been closely concerned in many of the changes which have occurred, is becoming more and more closely occupied with the technical development of the industry of the future Changes are occurring at an increasing tempo and the next decade is likely to see a much greater alteration in both techniques and organization than the previous 30 years have done

One of the major problems concerning our supply of white fish is that about half of it comes from Arctic waters The fishing grounds are anything from three days to one week's steaming from the Humber ports, on which almost all the long-distance trawlers are based, and this consequently sets a limit to the age of the freshest fish that can be landed Voyages are on an average of nearly three weeks duration and the fish caught first may therefore be 16–17 days old when it is landed Cod and haddock, even when properly stored in crushed ice, remain in reasonably good edible condition for only 14–15 days About ½ per cent per annum of the Arctic catch is in fact condemned at landing as unfit for human consumption After landing, the vicissitudes of the distribution chain may render passable fish unpleasant and good fish only passable

Since the Second World War, considerable attention has been paid at Torry to the problem of how to get fresher fish to the consumer A promising solution is to build a trawler capable of freezing the first third of the catch That the idea is practicable was shown in a full-scale trial carried out in 1955–56 under Torry's technical supervision and financed jointly by the Distant Water Vessel Owners' Development Committee, the White Fish Authority and H M Government A Grimsby trawler was fitted with vertical plate freezers developed at Torry and capable of operating satisfactorily in the exacting conditions of Arctic fishing, and with a − 30° C cold store The frozen fish was distributed to consumers throughout the country whose reactions were almost universally favourable The latest development is the design of a vessel of normal size and cost which would show attractive economic advantages over existing high-speed trawlers Such a vessel would be a trifle slower than the latter, the extra 1–2 knots of which are disproportionately expensive to obtain It could spend rather longer on the fishing grounds and therefore land a greater weight of fish The frozen part of the catch could be used to even out the supply from the summer glut to winter dearth

Another possible way of slowing down the rate of spoilage of fish is to use antibiotics such as chlortetracycline and oxytetracycline Much of the pioneer work has been carried out in Canada, where their use is now permitted, but they may not yet be used in the United Kingdom One of the major tasks in hand is to determine the quantities of these substances likely to get into and remain in the flesh after various types of storage, processing and cooking Even those antibiotics most effective in fish preservation have limitations ; there is little difference in the flavour of fish stored in plain water ice and in antibiotic ice up to about the tenth day, so that no more could be done than to keep fish that would otherwise become poor or very poor in a passable, but not really fresh, state

A recent survey carried out by staff of the Humber Laboratory and workers seconded by the White Fish Authority of the temperatures of fish during distribution from unloading from the trawler to sale from the fishmonger's slab has stimulated considerable interest within the trade and is already bringing about improvements in practice It represents another approach to the same problem of how the quality of fish reaching the consumer can be raised This survey is probably the first large-scale attempt in any country to obtain first-hand field data of this kind It is typical of much of the work carried out at Torry, since it was made possible only by the co-operation of the industry and was initiated by discussion with representatives of the fish trade

The Station necessarily supplements such practical applied investigations and development work with a considerable volume of basic research Thus, a greater understanding is being sought of the detailed structure and composition of fish tissues, and of their behaviour during processing such as freezing and cold storage, smoking and drying Knowledge is also being acquired of the composition of the bacterial flora of fish and the nature of the species mainly responsible for spoilage Studies since the War have contributed to improvements in the taxonomy of the marine bacteria mainly concerned and in the building up of a type culture collection now of international reputation

Solid progress in recent years in the characterization and estimation of the so-called 'extractives' of fish muscle is providing a clearer insight into the autolytic changes that take place immediately after death and during bacterial spoilage This work is of particular importance in understanding the various physico-chemical changes that occur during dehydration, freezing and subsequent storage of fish, as well as the factors which give rise to different types of spoilage flora under various conditions Recent years have also seen the accumulation of new knowledge of the main proteins of fish muscle which is serving in particular to explain the causes of textural change during freezing, cold storage and dehydration Mention should be made of the work on the Maillard 'browning' reactions which occur in dehydrated fish muscle

Considerable attention has been given to the prevention of oxidative rancidity in cold-stored fatty fish Fish fats are highly unsaturated, and frozen fatty fish such as herring remain in really edible condition for a shorter period than white fish The rate of oxidation of fish fat can be slowed down by 'glazing' ; this consists of dipping the frozen fish in water so that a layer of ice is formed around the outside Drying of fish in cold store hastens the development of rancidity , even more important, therefore, is to store fatty fish under conditions where drying is at a minimum Current work on the oxidation process may eventually lead to economic improvements It has been found that fat oxidation is catalysed by hæmatin pigments in the red lateral muscle which is present in a well-defined form only in fatty fish

Nevertheless, there are limits to the cold-storage period even of species like cod which contain considerably less than 1 per cent fat in the muscle , the fat becomes oxidized and there are progressive changes in the protein structure common to all fish Recently, a new method has been devised for assessing the development of toughness in cold-stored fish This depends upon the fact that although fresh unfrozen muscle can be macerated in dilute formalin solution to give a thick opaque suspension, there is a tendency for the fibres of frozen fish to resist maceration and this resistance increases as a function both of storage time and of storage temperature By determining the amount of light transmitted by the 'soup' of fish fibres produced under standard conditions it has been found possible to relate samples to a standard time/temperature curve This test, the validity of which requires further checking to cover a number of variables, is so simple that it could easily be adopted by the fish-freezing firms which, with one or two notable exceptions, do not employ scientifically trained staff and do not possess quality control or development laboratories

Fish freezes more rapidly than it thaws, due to the difference of thermal conductivity through frozen and unfrozen tissue For example, a block of fillets 4 in thick may freeze in 4 hr or so but may take 20 hr to thaw out in air at ambient temperatures A number of firms use large quantities of frozen fish for their products , for example, there is a variety of ready-cooked fish products prepared initially from frozen fish and sold in frozen consumer packs, and the kippering industry uses large amounts of frozen herring when fresh herring is not available At present, fish is thawed on a large scale, either by merely leaving the frozen blocks in air or by spraying with cold water The latter method, if it is carelessly carried out, may adversely affect the quality of the product, and both methods are time- and labour-consuming Attempts by workers in other countries to apply dielectric heating have not been successful, mainly due to 'runaway' heating This is the condition in which there is progressively increasing absorption of the available power in warm spots in the blocks, which become cooked , this is at the expense of the cooler portions, which remain frozen Recently this difficulty has been overcome and commercially available equipment has been slightly modified , a pilot plant has been running at Torry without trouble for the past six months or so Blocks of frozen fish can be evenly thawed in about 15 min The technological implications of this work are very wide indeed

The commercial smoking of fish is still largely carried out in the traditional smoking kiln which was developed during the early Middle Ages This is merely a chimney in which brined fish is hung and a sawdust and wood-chip fire lighted on the floor The operation takes anything up to 12 hr or more to complete The irregularity of natural convection, and the effect of warm humid weather on the functioning of the kiln, render fish-smoking an art which is difficult to practise In 1939 a mechanical kiln was developed at Torry which simplified the process and made it much easier to control Although the industry was at first slow to adopt the new kilns, an increasing number of firms are now doing so Intriguing possibilities are, however, now being suggested as a result of basic physical and chemical work on the composition of wood smoke It has been shown that virtually all the smoke constituents on smoked fish are derived from the invisible vapour phase and not the visible particulate phase The practicability of smoking fish with 'smokeless' smoke and further developments as well are envisaged

There is a continuous programme of work at Torry on the improvement of the efficiency of conventional fish-meal plant Emphasis is put upon methods of increasing production, plant efficiency and nutritive value of the product

It is important to stress that the high standing of the Torry Research Station within the fish industry itself is very largely due to the considerable amount of consultation and discussion which takes place with the industry and, not less important, the very good relationship built up between individual scientists and various people 'in the trade' Much of the development and survey work carried out within the past ten years would have been quite impossible without the close and friendly co-operation of the industry, on this personal contact between government research workers and the industry the future development of this relatively undeveloped and traditional industry, without any research organization of its own, depends

G H O Burgess

FISHERY RESEARCH

Dr BREDER has prepared a valuable review of work on social grouping in fish*, it also contains new data, though it is sometimes a little difficult to pick these out He discusses in detail the various types of groups the aggregation, where the individuals are not 'polarized', the school, where they are, and the pod, where the fish are in physical contact These types of groups are illustrated by outstandingly good photographs, those of pods and fish in 'orderly files' being the most interesting

Descriptions of new work are mainly of the effect of light intensity and colour on a number of species and the analysis of the internal structure of schools In the experiments on the effect of the wave-length of light the fish were given a choice between different colours, the intensity of the different colours being equated photometrically No attempt was made, by determining the spectral sensitivity of the fish, to equate the subjective intensity, or intensity as it appeared to the fish Of particular interest are Dr Breder's discussions on the leadership of schools, the school as a super-organism and the evolution of schooling behaviour There is also a section on schooling in terms of cybernetics, where the point is made that the survival of a species which has grouping tendencies should perhaps be considered from the point of view of how they have got over the danger involved, rather than that such tendencies automatically have survival value

Dr Loukashkin's and Dr Grant's work on *Sardinops caerulea**, a species of great commercial importance, has much in common with Dr Breder's but is more limited in extent It is again well illustrated with photographs Like other clupeoids, *Sardinops* is not an easy subject for experiment, but results have been obtained which show the importance of light for the maintenance of school formation and that fright reactions are elicited by red lights and by flashing white lights When given the choice between red, green, blue and white light, the fish avoided red and preferred blue and green to white As in Dr Breder's work, this technique has a limitation in that the intensities of the different colours were not equated subjectively but only photometrically

This type of behaviour work, which may be considered important as an aspect of fisheries research, is now being produced in much greater quantity than before the War, and it is particularly welcome to the fisheries research worker when it is concerned with species of commercial importance

J. H S Blaxter

* Bulletin of the American Museum of Natural History Vol 117, Article 6 Studies on Social Groupings in Fishes By C M Breder Jr Pp 393–482+plates 70–80 (New York American Museum of Natural History, 1959) 1 50 dollars

* Proceedings of the California Academy of Sciences Vol 29, No 15 Behavior and Reactions of the Pacific Sardine *Sardinops caerulea* (Girard) Under the Influence of White and Colored Lights and Darkness By A S Loukashkin and N Grant Pp 509–548 (San Francisco California Academy of Sciences, 1959)

THE ONTARIO RESEARCH FOUNDATION

THE annual report of the Ontario Research Foundation for 1958 (pp 36 Toronto Ontario Research Foundation, 1959) includes, besides the report of the director, Dr H B Speakman, a summary of the work of the various sections, a list of papers published during the year, the financial statement and details of the Board of Governors and professional and technical staff There is also a list of grants for postgraduate studies in science for the period 1958–59, for which grants in 1958 totalled 145,204 dollars In biochemistry three major projects, dealing with the development of an all-temperature biscuit spread for the Defence Research Medical Laboratories, tea, and the recovery of pure individual amino-acids from wheat gluten after hydrolysis, were completed, and two major studies are in progress under the Rice Mills Fellowship In chemistry, activity was maintained at a high level The three-year survey of air pollution of the Hamilton area was completed, while the development of gas chromatography proceeds apace In a study of factors controlling the crystallinity of polymers, techniques developed for preparing polymers of butane with 50 per cent of crystallinity are being used to study the relation between the type of catalyst and polymer structure A novel ion-exchange process for recovering ammonia from ammonia-base waste sulphite-liquor has been developed and a pilot plant constructed A comprehensive study has been continued of various sulphite-liquors and their fractions and has led to a patent application , there have been utilization studies on by-product lignin from the manufacture of vanillin, while research on phosphate glasses has been continued in the Na_2O—P_2O_5—H_2O system centred largely on the constitution of sodium acid glasses of intermediate composition, using filter paper chromatography

In engineering and metallurgy basic research was directed at the concentration of hæmatite by a combination of magnetic and mechanical methods or by roasting methods followed by magnetic separation In work on dry magnetic separators the 'Fast Eccentric Drum Separator' has been developed to the point of commercial production In basic research on the fatigue of metals three stages have been distinguished (*a*) the first four thousand cycles , (*b*) a slow steady decline in cyclograph (magnetic test) , and (*c*) the last 15,000–20,000 cycles in which the final crack is developing A precision camera was designed and built for stress determination in X-ray work

In the Department of Parasitology most of the work was a continuation of earlier projects, and persistent effort has provided an understanding of the prevalence and mode of transmission of some of the many parasites of Ontario's wild animals Similar studies on wild birds are in progress, and during 1958 the blood parasite of ducks, *Leucocytozoon simondi*, was successfully grown on tissue culture in test-tubes Continued studies of two types of blood parasites of birds have shown that certain types of black flies transmit them to ducks, while others transmit them to ruffed grouse In physics some fundamental work dealing with beams of electrons has been planned, while other projects included development of an atmospheric X-ray spectrometer, design procedures for dynamic pressure stages, determination of gas density by electron beams and high-energy applications of electron beams The Department of Physiography completed an extensive study of the fine sand fraction of representative soils and a five-year environmental study of soya bean is nearing completion Research on the chemical modification of wool continued in the Department of Textiles as well as a study of the colour fastness of spun-dyed viscose yarn Good progress is reported in the standardization of women's and children's garment sizes for the Canadian Government Specifications Board

INSTRUCTIONAL FILM RESEARCH IN PENNSYLVANIA

THE Pennsylvania Instructional Film Research Program was established in 1947 and terminated in 1955 Jointly sponsored by the U S Army and Navy, it represents the largest piece of co-ordinated research yet carried out on the teaching film Accounts of the early part of the research have appeared in *Nature*[1] It is the purpose of this article to complete the outline record by reviewing the last reports—now gathered into one volume[2]

The later work follows directly on the earlier, confirming it, filling in details and dealing with specific problems But some new and interesting notions of a general sort arise in this process The very last studies, 100–104, deal with training aids such as models and other apparatus that are not films Two of the studies, 46 and 50, are related to the use of films in psychotherapy These two studies, as well as study 60, are concerned with films which influence attitude The main classes of films dealt with in the research have been those which impart information and those which teach perceptual-motor skills

A number of the studies yield information of general practical use For example, study 37 by Philip Ash and Nathan Jaspen—see report *SDC* 269–7–37—examines optimum viewing conditions Using a small rear projection daylight screen in teaching a performance skill—the assembly of a gun breech block—the optimum viewing area was found to be a sector 60° wide and 12 screen-widths deep Increasing distance from the screen beyond 12 screen widths led to much sharper loss of teaching effectiveness than increasing angle of view beyond that of the 60° boundary Outside the optimum viewing area loss was greater under daylight than under dark viewing conditions These results may be compared with those found for a standard size screen and projector by J J Gibson[3] he found that within a sector up to 90° wide and 7 screen-widths deep there was no loss in teaching effectiveness

The Pennsylvania film research organization has always stressed that teaching films should be tested "with adequate samples of appropriate target audiences using reliable and valid tests", rather than by viewing panels Nevertheless, assessing teaching effectiveness by a viewing panel remains often the only practical alternative Study 57 by L P Greenhill investigates such assessing, and recommends a particular type of film analysis form (or questionnaire) , this panel testing procedure being used to select the best of several films, or to improve the teaching effectiveness of a film still under production Study 59 by A L Edwards provides a statistical methodology which might be used when assessing films by the panel method The report on study 48 about making simple demonstration films with untrained personnel includes—as an appendix—a 'manual for minimum film production'

Infra-red photography offers an excellent means of recording audience reactions—of children and others —under conditions of little or no visibility But infra-red motion photography is expensive Study 56, by L P Greenhill, investigates the less costly use of infra-red memo-motion photography This is essentially time-lapse photography The photographs were taken on 16-mm infra-red film at the rate of one a second, a rate which appears sufficiently frequent to show most types of human activity The record was synchronized with the events on the screen, by the synchronous drive of camera and projector, and more satisfactorily by the use of a mirror reflecting a small image of the screen into the camera—so as to appear at one corner of each memo record frame

In one of the earlier Pennsylvania studies[4] it was found that a rating profile for a film, showing peaks for an audience reaction of 'I am learning' and valleys for a reaction 'I am not learning', provided a valid index of learning. The subjectively based graph was found to be highly correlated with one based on the results of an objective learning test. This finding—although it has yet to be fully established—has considerable importance in connexion with film research, because it justifies a simple procedure in place of the present elaborate one of objective testing. In some measure it is further confirmed by study 55. In this study, by Richard M. Fletcher, it was found that a team of competent assessors could shorten film commentaries without reducing teaching effectiveness considerably more when aided by a learning profile than when not so aided—in one case 26 as against 11 per cent. However, Richard M. Fletcher says that the results of this study should be interpreted carefully. In an interesting discussion of results he considers the implications of the reactions 'I am learning' and 'I am not learning'.

The notion of 'realism' as a factor influencing the teaching effectiveness of films has received attention in early Pennsylvania studies, in relation to viewing angle[5], stereoscopy[6] and colour[7]. It emerges as a more conscious notion in the later work. In study 49 on the validity of pictorial tests and study 47 on the use of films in a Thematic Apperception Test, 'iconicity' is considered. This term derives from C. Morris's work. "A sign is iconic to the extent to which it itself has the properties of its denotata[8]." The study of the features and combinations of features that lead to life-likeness in films has been called by the present reviewer 'simulacrics'[9]. In listing eight hypotheses of film research it is possibly significant that the director of the Pennsylvania research should have given the sign similarity hypothesis first: "That films whose signals, signs, and symbols have high degrees of similarity ('iconicity') to the objects and situations which they represent will be more effective for most instructional purposes than films whose signals, signs, and symbols have low degrees of 'iconicity'[10]."

Report 40 provides a valuable bibliography of production, utilization and research on instructional films. It contains about 600 references dating up to the early part of 1952, arranged alphabetically by author.

One or two of the early Pennsylvania studies have been criticized on the grounds that they are directed towards findings that are obvious in the first place. Perhaps more justifiably one or two other of the Pennsylvania studies have been criticized because they have been concerned with teaching in general rather than teaching with films in particular. The Pennsylvania research includes relatively little basic research on the film medium itself. In general the method has been to carry out experiments using the prevailing current picture-cum-commentary type of instructional film, and consequently to improve that type.

But such comment on isolated studies and minor aspects of the Pennsylvania research seems almost out of place in view of the enlightened way it has been directed and all it has accomplished. In 1947 there was no body of experimentally attested principles about teaching films and no proved techniques of film research, which thanks to the Pennsylvania work exist now. This work—which might so easily have been restricted to fulfilling limited training needs—has yielded results of value to teachers generally and to psychologists. Credit is due to the associate directors C. R. Carpenter and L. P. Greenhill, who with some of their staff now form an organization at Pennsylvania State University that has already investigated the use of closed-circuit television in university teaching.

C. DENIS PEGGE

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[1] Pegge, C. D., *Nature*, **168**, 775 (1951); **170**, 962 (1952); **173**, 937 (1954).

[2] Technical Reports *SDC* 269-7-37 –59 and *SDC* 269-7-100 –104, obtainable singly or in one volume (*SDC* 269-7-61), from Special Devices Center, Port Washington.

[3] Gibson, J. J., Report No. 7, Army Air Forces Aviation Psychology Program (Washington, D.C., Government Printing Office, 1947).

[4] Twyford, L., Technical Report *SDC* 269-7-23 (Special Devices Center, Port Washington, 1951).

[5] Roshal, S. M., Technical Report *SDC* 269-7-5 (Special Devices Center, Port Washington, 1949).

[6] Cogswell, J. P., Technical Report *SDC* 269-7-32 (Special Devices Center, Port Washington, 1952).

[7] Vandermeer, A. W., Technical Report *SDC* 269-7-28 (Special Devices Center, Port Washington, 1952).

[8] Morris, C., "Signs, Language and Behaviour", 349 (New York, 1946).

[9] Pegge, C. D., *Audio-Visual Communication Review* (in the press).

[10] Carpenter, C. R., *Audio-Visual Communication Review*, **1**, 1 (1953).

BLOOD GROUPING OF THE REMAINS OF SWEDENBORG

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EMANUEL SWEDENBORG was born on January 29, 1688, and died in London on March 29, 1772. He was interred in the vault of the Swedish church in London. His remains were disturbed on several occasions; an account of these was given by Hultkrantz[1]. The coffin was first opened in 1790, and there is little doubt that this unauthorized action made the removal of the skull possible. The vault was opened at least nine times between this date and 1816. It has been suggested that a skull was stolen from the coffin on two occasions between 1816 and 1817. In consideration of the vogue enjoyed by phrenology at this time, this is not a remarkable fact. On the first occasion the instigator was probably the famous phrenologist Captain Holm, whose collection already included the skulls of Alexander Pope and Casimir Périer. The presence of a Swedenborg skull in his collection was disclosed to his niece in 1845, but regarded as a family secret. There is some evidence that Holm introduced a substitute into the coffin. In a letter to *The Times* of April 4, 1823, Hawkins states that the skull was removed in 1817, by Captain Granholm, a Swedish sailor, for financial gain. On his death this skull passed into the possession of Wahlin, pastor of the Swedish church in London. A skull claimed to be that of Swedenborg was in the collection of Charles Tulk, M.P., in the years prior to 1823, and it is thought possible that Wahlin gave it to him for safe keeping Tulk had casts made of this skull just before it was replaced in the coffin on March 25, 1823, in the presence of Wahlin This is the skull now present in the coffin There is no conclusive evidence as to its authenticity in the documents available In 1908 a letter was received at the Swedish Legation in London, from an individual claiming to have seen Swedenborg's skull in the collection of an antiquary in the 1870's It would seem probable that this is the skull from Holm's collection, but the evidence obtained to date is not conclusive This skull was traced, and is now in the possession of Dr Charlotte Brandt Distinction between the two skulls would appear to be possible only by means of objective scientific tests These have now been undertaken by Prof Folke Henschen and his colleagues in Stockholm, and at his request blood group analysis has been carried out at the British Museum (Natural History)

The material available from Uppsala consisted of portions of the parietal and mastoid bones of the skull (treated as one specimen in the blood grouping tests), a metacarpal bone, part of the right femur, fragments of a cervical vertebra and soft tissue from two regions of the right arm The last two samples included portions of cloth The English' skull, which has been described elsewhere[2], was entrusted to us by the present owner, Dr Charlotte Brandt Measurements of this skull are available in the records of the British Museum (Natural History) and a full description will be published with the complete account of studies on the remains of Swedenborg in the *Acta Regiae Societatis Scientiarum Upsaliensis* From this skull a section of the left parietal bone was cut out with a high-speed circular slitting saw, and diploic tissue removed with a dental drill This method has allowed replacement of the section without visible evidence of the action of the saw or drill The removal of sufficient material for testing would not have been possible from a skull by other methods without visible damage Bone from the skeleton was also prepared by drilling or by pulverizing in a mortar The flesh samples were separated as nearly as possible from the accompanying cloth with forceps

The technique of blood grouping employed is essentially similar to that discussed by Boyd and Boyd[3] and modified by Candela[4] for application to bone This technique is one in which evidence of the presence of a group specific antigen may be presumed if antiserum of suitable strength is inhibited in its activity with red cells of the appropriate group, after it has been in prolonged contact with the tissue sample Four naturally occurring human anti-A sera and four anti-B sera were used on each specimen, where the quantity of material available permitted this These were diluted to bring the resulting titres of absorbed and unabsorbed sera to a convenient level for titration purposes It was found that for any one serum these titres always fell within a range of three tubes Titrations were carried out with a fresh 2 per cent suspension of A_2 and B cells[5] In all cases these antisera were known to give satisfactory results with control material of known blood group (that is, typed during life)

Candela's technique has been slightly modified, as follows 0 2 gm of prepared tissue was placed in a 75 × 10 mm tube and 0 4 ml antiserum added to each sample After careful mixing the tubes were placed in the refrigerator for 24 hours, and at the end of that time centrifuged at moderate speed for 2–3 min The supernatant was removed to a clean tube, using a Pasteur pipette with a small cotton-wool wad around the tip[6] If bone particles had not been completely removed, the tubes were re-spun Titration was carried out as described by Boorman and Dodd[5] Buffered saline containing 1 per cent sodium azide as proservative was used throughout No result has been accepted as positive unless a consistent inhibition was observed with any one serum over the entire series of tests Results in all cases are based on a series of at least four tests on the same sample, using a technique of replacement of the same antiserum Table 1 shows the inhibition values for the femur from Uppsala, on one anti-A and one anti-B serum from the series It illustrates the standard of inhibition on which the determination of the blood group has been based

Table 1

Test No	Serum					
	Anti-A			Anti-B		
	1 16	1 32	1 64	1 64	1 128	1 256
1	+	–	–	++	+	(+)
Control	+++	++	+	++	+	w
2	+	–	–	++	++	+
Control	++	+	w	++	++	+
3	(+)	–	–	+++	++	w
Control	+++	++	+	+++	++	w
4	++	(+)	–	++	+	vw
Control	++	+	w	++	+	w

In at least one other laboratory anti-A sera are reversed with anti-B sera on each sample (Gray, personal communication) This method could be unreliable because of the presence of alcohol-soluble group substances in all sera[7], and it has not been found to give clear results in this laboratory In using a replacement technique over a series of tests it has been found possible to confirm or reject results which on first testing appear doubtful, and this method is therefore preferred

The Uppsala remains were tested together, but the 'English' skull was not obtained at the same time, and was therefore tested in conjunction with a further sample of the Uppsala skull at a slightly later date All this material had a very fresh appearance, giving a strong smell on drilling The diploic tissue of the 'English' skull, in particular, appeared to contain a large quantity of organic matter, but when allowance had been made for the different environmental conditions in which each had been preserved, no difference of sufficient significance could be observed which would allow of any distinction in the historical age of the two specimens (Table 2) Fluorescence under ultra-violet lamp showed no distinction between the two skulls in comparison with the long bones

Table 2

Nitrogen content of the material

Coffin skull	4 5–4 8 mgm	nitrogen per 100 mgm bone
'English' skull	3 9–4 1 mgm	nitrogen per 100 mgm bone
Coffin femur	4 4– mgm	nitrogen per 100 mgm bone

In discussing the results obtained on these bones, it is relevant first to consider the present-day distribution of the ABO groups in Sweden Jesper Swedberg, father of Emanuel, came from Dalekarlia although his mother was of German origin Figures for this area of Sweden are available from the paper by Beckman[8] (Table 3)

Table 3

	No.	O	A	B	AB	*p*	*q*	*r*	*D*/σ
Beckman (Kopparberg) (conscripts)	7,952	39·94	44·05	11·54	4·46	28·28	8·36	63·36	+ 1·33
London*	37,216	46·43	41·57	9·16	2·85	25·53	6·23	68·27	0·70

* Means of six series quoted in ref. 9 (the small series of Dyke being omitted).

It will be seen from these figures that a high frequency of group A is characteristic of the population. Assuming the possibility that the Uppsala skull, if a substitute, may have been English, we must also consider the distribution of the ABO groups in London (Table 3).

Inhibitions obtained from this material, although not strong, were consistent, with the exception of the flesh samples. In these, while a clear inhibition for group A was obtained, some inconsistent absorption was seen with anti-B sera. Conclusions as to the blood group of the skeleton have been based, therefore, on the results obtained from the femur, the cervical vertebra, and the metacarpal bone. These give inhibition of all anti-A sera, and none with anti-B sera. The Uppsala skull shows the same result. The 'English' skull failed to show any inhibition with any anti-B serum and with one of the four anti-A sera, and had ceased to inhibit the three remaining anti-A sera at the fourth test. In view of the very clear evidence offered with anti-B sera it is felt that the interpretation of these results may be made with confidence, and the presence of group A-specific substances postulated in all the samples. As has already been noted, the distribution of this blood group in the postulated areas of origin of the material made this result probable. It has not proved possible, therefore, to distinguish between the two skulls on the evidence afforded by blood grouping.

In considering the possibility that these results may be due to the presence of contaminants, it must be borne in mind that in consideration of the known history of the bones, it might reasonably be inferred that they had not been buried in soil. The evidence offered by Thieme, Otten and Wheeler[10] on the action on group-specific substances of certain anaerobic saccharolytic bacteria present in soil might therefore be considered irrelevant to the present study. It has been suggested that substances present in the soil, such as the Forssman antigen, may give results ascribable to group A substances[11], but no evidence has been brought forward. Other sources of bacterial activity remain possible, however, and it was thought to be of interest to submit unlabelled samples of both skulls and of the femur from the coffin to Drs. Allison and Perkins, of the National Institute for Medical Research, for the detection of bacterial contamination. Acid hydrolysates of this material were submitted to paper chromatography, for the detection of muramic acid and diaminopimelic acid. These are known to be constituents of bacterial cell-walls, but have not been detected in human tissues. These substances could not be shown to be present in the Swedenborg material. This result excludes gross bacterial contamination, but it remains to be shown whether the presence of bacteria in amounts sufficient to absorb blood group antibodies can be detected by the chromatographic technique. Should this prove to be so, the use of this technique in conjunction with the blood grouping of tissues should prove a valuable tool to the palæo-serologist.

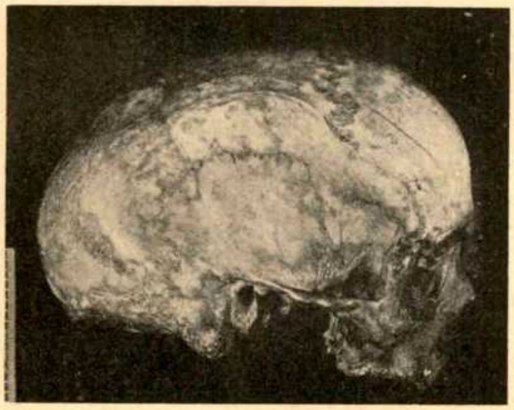


Fig. 1. The 'English' skull attributed to Emanuel Swedenborg. (*Norma lateralis*)

As it was reported (Henschen, personal communication) that large quantities of lead salts were present in the bones, a study was made on control material of known blood group to determine whether increased quantities of lead salts would affect the results of blood testing. The normal quantity of lead present in the long bones is 1·88 mgm. per 100 gm. In a series of tests this quantity was increased until it reached twice the normal value. No effects on the results of blood grouping were noted.

While the use of palæo-serological technique has proved its value in the identification of human remains, it has not contributed to any decision in the case discussed here. However, it has been established that on the basis of blood grouping the 'English' skull has an equal claim with the Uppsala skull to be that of Swedenborg, and that it should be included in further investigations. Tests being carried out in Sweden, under the direction of Prof. Henschen, may prove of greater assistance in distinguishing between the two skulls. It is expected that results of their examination will be published in the *Acta Regiae Societatis Scientiarum Upsaliensis*.

I am indebted to Mr. G. C. Ross for the estimations of nitrogen content of the bones quoted in this communication.

[1] Hultkrantz, J. Vilh., *Nova Acta Regiae Soc. Sci. Upsaliensis.*, Ser. IV, 2, No. 9 (1910).

[2] Rutherford, W., *J. Anat. Physiol.*, Ser. 3, **9** (1913).

[3] Boyd, W. C., and Boyd, L. G., *J. Immun.*, **26**, No. 6 (1931); *Proc. Soc. Exp. Biol. Med.*, **81**, 671 (1934).

[4] Candela, P. B., *Amer. J. Phys. Anthrop.*, **21**, No. 3 (1936).

[5] Boorman, K. E., and Dodd, B. E., "An Introduction to Blood Group Serology" (Churchill, London, 1957).

[6] Candela, P. B., *Amer. J. Phys. Anthrop.*, **25**, No. 2 (1939).

[7] Hartmann, Grethe, "Group Antigens in Human Organs" (Ejnar Munksgaards F., Copenhagen, 1941).

[8] Beckman, L., *Hereditas*, **43**, 423 (1957).

[9] Mourant, A. E., Kopeč, Ada C., and Domaniewska-Sobczak, Kazimiera, "The ABO Blood Groups" (Blackwell, 1958).

[10] Thieme, F. P., Otten, C. M., and Wheeler, A. H., "Biochemical and Immunological Identification of Human Remains", Report under project 7-64-12-004*C* QM, Research and Development.

[11] Salazar Mallen, M., *Gac. Med. Mex.*, **81**, 122 (1951), quoted in Mourant, A. M., "Distribution of the Human Blood Groups" (Blackwell, 1954).

ABNORMAL HUMAN HÆMOGLOBINS

Human Hæmoglobin *E*: the Chemical Effect of Gene Mutation

THREE of the many abnormal variants of human adult hæmoglobin (*A*) occur in high frequency in certain areas of the world. They are sickle cell hæmoglobin (*S*), hæmoglobin *C* and hæmoglobin *E* (ref. 1). All these are thought to be caused by mutant genes inherited in a Mendelian manner. Such evidence as is available suggests that the genes for hæmoglobins *S* and *C* are allelic or closely linked[2]. The only family so far known in which hæmoglobin *E* occurred with another abnormal hæmoglobin (*S*) was one studied in Turkey by Aksoy and Lehmann[3]. The evidence for allelism, or close linkage, of the two genes was conflicting, but the authors felt that it was more in favour of allelism than against.

Comparisons of the chemical structure of hæmoglobins *S* and *C* with that of normal hæmoglobin (*A*) have not only confirmed the allelic nature of the hæmoglobin *S* and *C* genes, but have also shown the effects of these mutations on the primary chemical structure of hæmoglobin[4]. We now wish to report similar studies on hæmoglobin *E* which we undertook in order to investigate the chemical effect of this mutation and the chemical and genetic relationship between hæmoglobin *E* and the other abnormal hæmoglobins.

Hæmoglobin *E* was discovered in 1954 by Itano, Bergren and Sturgeon[5] in an American patient of Guatemalan, Spanish and Hindu origin—and in his family—by its abnormal electrophoretic mobility. The gene for hæmoglobin *E* has since been found with high incidences among Burmese and Siamese and some Indonesian, Ceylonese and Malaysian populations[6]. Single instances have been found in India, Persia, the Philippines[6], and among the Eti-Turks[3] (who have a high incidence of the sickle cell gene). It is interesting to note that the hæmoglobin *E* gene is found with high frequency in south-east Asia, whereas the hæmoglobin *S* and *C* genes are found in highest incidence among the Negroes of Africa[1]. In other words, they are geographically widely separated, but all three forms resemble one another in occurring very much more frequently than the other abnormal hæmoglobins. The chemical relationship between hæmoglobins *A*, *S* and *C* was reported by us[4] to be very close indeed, since it involved a replacement of the same glutamyl residue in hæmoglobin *A* by a valyl residue in hæmoglobin *S* and a lysyl residue in hæmoglobin *C*. Since the countries in which the hæmoglobin *S* and *C* genes occur are close together, and since the gene for hæmoglobin *E* occurs mostly in a separate region, it seemed possible that hæmoglobin *E* is not so closely related to *S* and *C*. This was found to be the case; a different part of the hæmoglobin molecule is affected by the mutational change.

On moving-boundary or paper electrophoresis at *p*H 8·6 (ref. 7) hæmoglobin *E* moves close to hæmoglobin *C* but slightly faster; on the other hand, at *p*H 6·5 its position is close to hæmoglobin *S*, though just behind it. This contrasts with the behaviour of hæmoglobins *A*, *S* and *C*, which migrate in the same relative order at *p*H 8·6 and at *p*H 6·5, hæmoglobin *A* being the fastest and hæmoglobin *C* the slowest. The intervals between them are almost equal. Hence, the effective net charge difference between hæmoglobins *A* and *E* at *p*H 6·5 cannot be the same as that between hæmoglobins *A* and *C*. The amino-acid compositions of hæmoglobins *A* and *E* are not significantly different[7]. The number of sulphydryl groups found by amperometric titration are the same in both hæmoglobins *A* and *E* (ref. 7); the solubility of hæmoglobin *E* is about the same as hæmoglobin *A* (ref. 5). Hence the difference between the hæmoglobins *A* and *E* is likely to be small and probably involves charged groups.

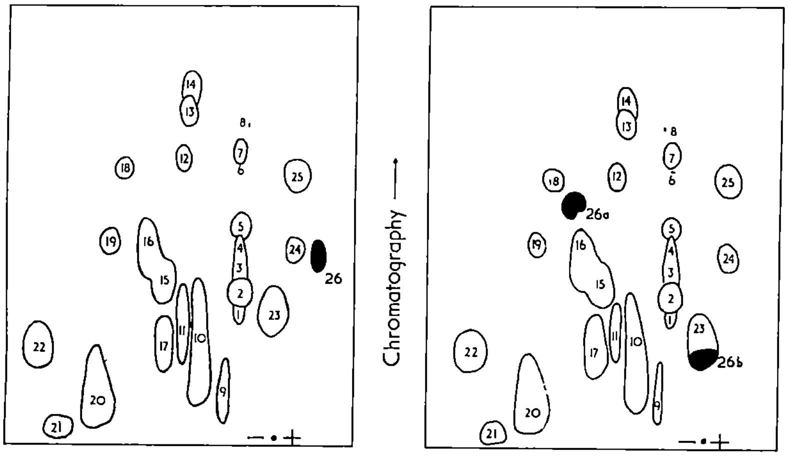
In the present work, hæmoglobin *E* from individuals known to be homozygous for the hæmoglobin *E* gene was denatured by heat at *p*H 8. It was then digested with trypsin at *p*H 8, following the course of the breakdown by alkali uptake in a *p*H-stat[4]. At the end of the reaction a core resistant to trypsin was precipitated at *p*H 6·5. Treatment with hydrochloric acid–acetone removed the hæm group from the core, which could then be completely solubilized by digestion with chymotrypsin[4].

Such tryptic and chymotryptic digests of hæmoglobin *E* yielded mixtures of peptides which were compared with those of hæmoglobin *A* in two ways. First, they were separated by fingerprinting[4], and secondly, by paper electrophoresis in the pyridine–acetic acid buffer at *p*H 6·4 (ref. 8) and examination of the peptide bands so formed by descending chromatography with *n*-butyl alcohol/acetic acid/water (4 : 1 : 5)[9].

When fingerprints of the chymotryptic and tryptic digests of hæmoglobin *E* were compared with those of hæmoglobin *A*, all the peptides occupied the same positions except peptide 26, which had been replaced by a new peptide, called 26*a*, in the hæmoglobin *E* tryptic digest (Fig. 1). Separation of the peptides by the second method revealed another new peptide, called 26*b*, in the tryptic digest of hæmoglobin *E*. It therefore appears that one peptide present in the tryptic digest of hæmoglobin *A* is replaced by two new ones in hæmoglobin *E*. No other changes have so far been found. Within the limits of our experimental method[4], the amino-acid compositions of the unchanged peptides in the tryptic and chymotryptic digests were found to be the same in hæmoglobins *A* and *E*.

The hæmoglobin peptides *A*–26, *E*–26*a* and *E*–26*b* were isolated by eluting the appropriate peptide bands obtained by paper electrophoresis of the tryptic digests at *p*H 6·4. The hæmoglobin *A* peptide 26 required no further purification. The hæmoglobin *E* peptide 26*a* was purified by repeating the electrophoresis at *p*H 6·4, and the hæmoglobin *E* peptide 26*b* by descending chromatography with *n*-butyl alcohol/acetic acid/water (4 : 1 : 5)[9].

The amino-acid sequences of the differing peptides were determined by the techniques of Sanger[10] and of Edman[11]. Quantitative amino-acid analysis by two-dimensional paper chromatography[12] showed the composition of the hæmoglobin *A* peptide 26 and those of the hæmoglobin *E* peptides 26*a* and 26*b* to



Haemoglobin A

Haemoglobin E

Fig 1 Tracings of fingerprints of the trypsin digests from hæmoglobin *A* and *E*

be as shown in Table 1 The composition of the hæmoglobin *A* peptide has been confirmed by analysis on the 'Spinco' Model 110 Moore and Stein automatic analyser When the compositions of the two hæmoglobin *E* peptides are added, they account for all the amino-acids present in the normal peptide with the addition of a single lysine residue in place of a glutamic acid

Table 1 COMPOSITION OF HÆMOGLOBIN *A* PEPTIDE 26 AND OF HÆMOGLOBIN *E* PEPTIDES 26*a* and 26*b* (EXPRESSED AS RESIDUES OF AMINO-ACID PER MOLE OF PEPTIDE)

	Hæmoglobin *A* peptide 26	Hæmoglobin *E* peptide 26*a*	26*b*
Aspartic acid	2	—	2
Glutamic acid	2	—	1
Alanine	1	1	—
Glycine	3	1	2
Leucine	1	1	—
Valine	3	—	3
Arginine	1	1	—
Lysine	—	—	1

Partial amino-acid sequences of the peptides were obtained from the results of partial acid hydrolysis, and end-group determinations of the fragments by Sanger's 1-fluoro-2,4-dinitrobenzene method[11] The N-terminal sequences of the hæmoglobin *A* peptide 26 and the hæmoglobin *E* peptide 26*b* were found by examining the dinitrophenol-peptides obtained by partial acid hydrolysis of the dinitrophenol-derivatives of the two peptides, and also by three steps of the Edman degradation[11] using the modification of Sjoquist[13] The remaining portion of the sequence of the hæmoglobin *A* peptide 26 was finally determined by digestion with elastase[14] and quantitative amino-acid analysis[12] of the resulting fragments When the peptide was heated in dilute acetic acid[15], it was found that nearly two molecules each of aspartic acid and valine had been split from the peptide, leaving the rest intact As shown in Fig 2, it is still not yet possible to give a complete sequence for the hæmoglobin *E* 26*b* peptide, although peptides of structure glu(val,gly) and val-gly must be fitted into the undetermined region in some way It is highly likely that the sequence in the hæmoglobin *E* 26*b* peptide corresponds exactly to that of the hæmoglobin *A* 26 peptide segment except that the C-terminal lysine replaces the glutamic acid in hæmoglobin *A* 26 peptide

Hæmoglobin *A* 26 val-asp-val- asp-glu-val-gly -gly - *glu* - ala-leu-gly-arg
Hæmoglobin *E* 26*b* val-asp-val-(asp-glu-val-gly)-gly - *lys*
26*a* ala-leu-gly-arg

Fig 2 Amino-acid sequences of hæmoglobin *A* peptide 26 and of hæmoglobin *E* peptides 26*a* and 26*b*

The occurrence of amide groups in these peptides has yet to be investigated, but the electrophoretic behaviour of the parent hæmoglobins *A* and *E* suggests that the glutamic acid which is replaced has a free carboxyl group

It is assumed that hæmoglobin *E* contains two equal half-molecules, as do hæmoglobins *A* and *S* (ref 16) Fig 2 shows that the change in hæmoglobin *E* resides in a replacement of a glutamyl residue of hæmoglobin *A* by a lysyl residue in hæmoglobin *E* This is the only difference so far detected among nearly 300 amino-acids of the hæmoglobin half-molecule The amino-acid substitution is like that found in hæmoglobin *C* (ref 4), involving a change of two charges, and the two proteins have a similar electrophoretic mobility at *p*H 8 6, but in this case it occurs in a different tryptic peptide and hence in a different part of the protein molecule

It is interesting to note that, just as in the case of hæmoglobins *S* and *C*, the genetic mutation which is responsible for producing hæmoglobin *E* expresses itself as a replacement of a single amino-acid by another We can only guess that this alteration is somehow functionally important, and confers a selective advantage on its bearer which is sufficiently high to account for its frequent occurrence[17] The chemical mechanism underlying the effect is as yet obscure The amino-acid change which we find explains the electrophoretic mobility of hæmoglobin *E* at *p*H 8 6, but not its behaviour at *p*H 6 5 While it cannot be stated with complete assurance that there is no other amino-acid alteration in the hæmoglobin *E* molecule, no other charge difference has so far been detected among the peptides, nor have any differences in their amino-acid compositions been found

Aksoy and Lehmann[3] have suggested that the gene for hæmoglobin *E* is an allele of, or closely linked to, the gene for hæmoglobin *S* (and hence to that for hæmoglobin *C*) In these last two proteins the change in the identical amino-acid suggests that the mutations occupy identical loci in the deoxyribonucleic acid chain forming the hæmoglobin gene The locus of the hæmoglobin *E* mutation is likely to be some distance away from the *S* and *C* loci, but may, nevertheless, be closely linked in the usually accepted genetic sense The finding that peptide 4 (hæmoglobin *S* and *C* mutations) and peptide 26 (hæmoglobin *E* mutation) are found to be in the same β-peptide chain of hæmoglobin[18] supports the idea of close linkage

We wish to thank Drs H Lehmann and E R Huehns (London) for generously supplying the samples of hæmoglobin *E* used in this investigation, Dr G Braunitzer (Munich) for his gift of a large quantity of hæmoglobin *A* peptide 26, and Drs M F Perutz and F H C Crick (Cambridge) and Dr H Lehmann for their helpful interest in this work One of us (J A H) is indebted to the Medical Research Council for a Scholarship

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[1] Aksoy, M , Bird, G W G , Lehmann, H , Mourant, A E , Thein, H , and Wickremasinghe, R L , *J Physiol* , **130**, 56*P* (1955) Itano, H A , "Advances in Protein Chemistry", **12**, 215 (1957) Neel, J V , "Hemoglobin", 253 (Pub 557, National Academy of Sciences—National Research Council, Washington, D C)

[2] Ranney, H M , *J Clin Invest* , **33**, 1634 (1954)

[3] Aksoy, M , and Lehmann, H , *Nature*, **179**, 1248 (1957)

[4] Ingram, V M , *Nature*, **178**, 792 (1956), **180**, 326 (1957) Hunt, J A , and Ingram, V M , *ibid* , **181**, 1062 (1958) Ingram, V M , *Biochim Biophys Acta*, **28**, 539 (1958) Hunt, J A , and Ingram, V M , *ibid* , **28**, 546 (1958)

[5] Itano, H A , Bergren, W R , and Sturgeon, P , *J Amer Chem Soc* , **76**, 2278 (1954)

[6] Lehmann, H , and Bhagwan Singh, R , *Nature*, **178**, 695 (1956)

[7] Jonxis, J H P , Huisman, T H J , Van der Schaaf, P C , and Prins, H K , *Nature*, **177**, 627 (1956) Stein, W H , Kunkel, H G , Cole, R D , Spackman, D H , and Moore, S , *Biochim Biophys Acta*, **24**, 640 (1957)

[8] Michl, H , *Monatsh Chem* , **82**, 489 (1951)

[9] Partridge, S M , *Biochem J* , **42**, 238 (1948)

[10] Sanger, F , and Tuppy, H , *Biochem J* , **49**, 463, 481 (1951) Sanger, F , and Thompson, E O P , *Biochem J* , **53**, 353, 356 (1953)

[11] Fraenkel-Conrat, H , Harris, J I , and Levy, A L , "Methods of Biochemical Analysis", **2**, 359 (1955)

[12] Redfield, R R , *Biochim Biophys Acta*, **10**, 344 (1953) Hunt, J A (unpublished work)

[13] Sjoquist, J , *Arkiv Kemi*, **11**, 129 (1957)

[14] Naughton, M A , and Sanger, F , *Biochem J* , **70**, 4*P* (1958)

[15] Partridge, S M , and Davis, H F , *Nature*, **165**, 62 (1950)

[16] Perutz, M F , Liquori, A M , and Eirich, F , *Nature*, **167**, 929 (1951) Schroeder, W A , Rhinesmith, H S , and Pauling, L , *J Amer Chem Soc* , **79**, 4682 (1957)

[17] Lehmann, H , *Blood*, **13**, 302 (1958), also in "Abnormal Hæmoglobins", 307, edit by Jonxis and Delafresnaye (Blackwell, Oxford, 1959)

[18] Ingram, V M , *Nature* (in the press)

Hæmoglobin 'Bart's': a Fœtal Hæmoglobin without α-Chains

In a previous communication one of us reported[1] that normal fœtal hæmoglobin (*F*) consists of two kinds of polypeptide chains One of these (α) is identical with the α-chain of adult hæmoglobin, while the other (γ) is different from its adult counterpart (β) and seems to be characteristic of the fœtal form (To avoid confusion in nomenclature of the hæmoglobin chains, it has been decided to call the chains of hæmoglobin *F*, α and γ and not α and β-fœtal as in ref 1) A fœtal hæmoglobin with an abnormally high anodic electrophoretic mobility was discovered at St Bartholomew's Hospital in an infant whose red-cell morphology resembled that seen in thalassæmia[2] It was called hæmoglobin 'Bart's' We have now found that this consists of γ-chains only

Fresh blood from an infant with hæmoglobin 'Bart's' was made available by the courtesy of Dr H Kohler, of Birmingham A purified solution, containing about 4 mgm of hæmoglobin 'Bart's' in 15 ml, was obtained by elution from paper electrophoretograms This solution was adjusted to *p*H 6 9 and heated in a boiling water-bath for 20 min to precipitate the hæmoglobin This was dissolved in 0 1 *N* hydrochloric acid and the hæm extracted with acid acetone[3] The dried globin was suspended in 0 6 ml of 2 per cent ammonium bicarbonate buffer at *p*H 7 9, and digested by addition of 0 05 mgm of trypsin at 38° C After 2 hr the solution was evaporated and re-evaporated from acetic acid to sublime the ammonium carbamate formed A solution of chromatographically purified hæmoglobin *F* (ref 1) of the same concentration was treated in exactly the same way in a parallel experiment The digests were compared with a normal tryptic digest[1] of hæmoglobin *F* by both one-dimensional paper electrophoresis at *p*H 6 4 and by fingerprinting[4]

The 'fingerprint' of hæmoglobin 'Bart's' is shown in Fig 1 in comparison with those of hæmoglobin *F* and the α- and γ-chains of hæmoglobin *F* (ref 1) It is apparent that all the α-chain peptides are missing from hæmoglobin 'Bart's' and that it consists solely of γ-chains Its sedimentation constant is indistinguishable from that of *A* (R A Kekwick), which suggests that its molecular weight is about 68,000 and the globin a tetramer

Jones, Schroeder, Balog and Vinograd[5] have found that hæmoglobin *H* consists solely of β-chains of adult hæmoglobin associated in a tetramer Hæmoglobin 'Bart's', therefore, is the exact counterpart in the fœtal system of hæmoglobin *H* in the adult system Hæmoglobin *H* is only found in the presence of the gene for thalassæmia The blood picture of infants with hæmoglobin 'Bart's' is like that in thalassæmia, but this does not persist into later life, nor do the children develop an abnormal hæmoglobin There are then two possible explanations for the production of an all γ-chain hæmoglobin There may be an over-production of the γ-chains However, from our present data we cannot be certain that there does not exist a small chemical difference between the γ-chains in hæmoglobin 'Bart's' and those in hæmoglobin *F* Alternatively, the production of α-chains may be inhibited, in which case, since the children with hæmoglobin 'Bart's' do not develop hæmoglobin *H*, the α-chains of hæmoglobin *A* and *F*, although chemically identical, do not appear to be controlled by the same gene Thus in a Greek boy with thalassæmia in whom, as is typical for this condition, hæmoglobin *F* had persisted beyond the age of infancy, a small amount of hæmoglobin 'Bart's' was

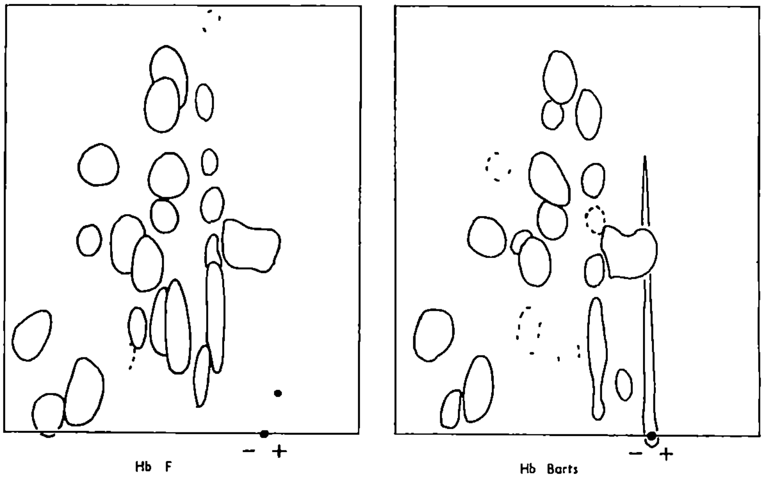

Fig 1 Tracings of fingerprints of the tryptic digestions of hæmoglobin 'Bart's' and hæmoglobin *F*

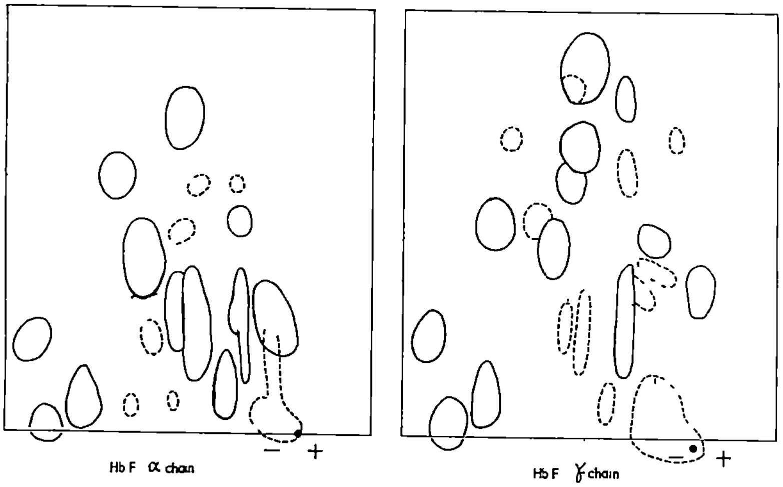

Fig 2 Tracings of fingerprints of the tryptic digestions of the chains of hæmoglobin *F*

also found but no hæmoglobin *H*[6] This could be interpreted as demonstrating the independence of the production of the α-chains for hæmoglobins *A* and *F* On the other hand, in an adult woman from Israel with a thalassæmia-like blood picture, more than 80 per cent of hæmoglobin *A* and only traces of hæmoglobin *F* were found, but 8 per cent of hæmoglobin 'Bart's' and 5 per cent of hæmoglobin *H*[7] Of her four children one also possessed hæmoglobins *A*, 'Bart's' and *H*, but only a trace of *F* This represents a strong inhibition of the fœtal α-chain formation with only a weak inhibition of that of the α-chains for hæmoglobin *A*

Several infants with hæmoglobin 'Bart's' have now been seen, always associated with normal hæmoglobin *F*, and it is interesting that in these infants the γ-chains of fœtal hæmoglobin should be capable of a separate existence, even though α-chains are being produced for both hæmoglobins *A* and *F* No reports of hæmoglobin consisting entirely of α-chains have yet appeared, but it would not be surprising if such chains could also exist on their own

One of us (J A H) is grateful to the Medical Research Council for a scholarship

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[1] Hunt, J A *Nature*, 183, 1373 (1959)
[2] Ager, J A M , and Lehmann, H , *Brit Med J* , i, 929 (1958)
[3] Anson, M L , and Mirsky, A E , *J Gen Physiol* , 13, 469 (1930)
[4] Ingram, V M , *Biochim Biophys Acta*, 28, 539 (1958)
[5] Jones, R E , Schroeder, W A , Balog, J E , and Vinograd, J R , *J Amer Chem Soc* , 81, 3161 (1959)
[6] Choremis, C , Zannos, L , Ager, J A M , and Lehmann, H , *Brit Med J* , ii, 348 (1959)
[7] Ramot, B , Sheba, C , Fischer, S , Ager, J A M , and Lehmann, H , *Brit Med J* (in the press)

MECHANISM OF IMMUNOLOGICAL UNRESPONSIVENESS

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CONDITIONS of immunological unresponsiveness which vary in specificity, completeness and duration have been induced in new-born rabbits by administering small amounts of soluble proteins at birth[1–4], and in adult rabbits by the injection of massive doses[5] of antigens, or by the prolonged administration of moderate amounts of antigens[6,7] In the hope of emphasizing pathways of antigen distribution that are essential for the establishment of an immune response, studies were undertaken to determine whether the fate of labelled antigen in unresponsive rabbits differs from the fate in normal rabbits which are potentially responsive[8] For this purpose, New Zealand white rabbits were rendered specifically unresponsive by means of repeated intraperitoneal injections of iodoproteins begun within 12 hr of birth[9] The iodo-ovalbumin and the iodobovine serum albumin which were injected contain 8–10 per cent of iodine and when injected intraperitoneally to normal adult rabbits they consistently evoke the production of precipitating humoral antibodies specific, in part, for their determinant diiodotyrosine residues

In no case, however, were precipitating antibodies found in the sera of rabbits which had been injected repeatedly 4–6 months from the time of birth The methods used to trace the iodoproteins were essentially the same as those employed in previous studies[8] Preparations of the iodoproteins labelled with iodine-131 were injected intravenously to normal and unresponsive rabbits Measurements were made after intervals of 2 min –24 hr of that portion of the persisting iodine-131 that was insoluble in aqueous 7 per cent trichloracetic acid and in neutral alcohol and acetone Because the radioactive iodine is an integral part of the determinant groups of the iodoproteins, it is felt that measurements of protein-bound iodine-131 trace the fate of material that is potentially antigenic, possibly in contrast to measurements of the total persisting isotope It was found that the labelled iodoproteins were eliminated from the blood and distributed among the organs of unresponsive rabbits in the same way as in normal, adult rabbits After a day, less than 0 5 per cent of the total injected iodoprotein remained in the blood of rabbits of both types Since the inability to form antibody induced by the present procedures does not result in a persistence or 'tolerance' of the antigens in the unresponsive rabbits, there is no evidence that the iodoproteins are 'recognized-as-self' by the unresponsive rabbits, or that the unresponsiveness depends on a mechanism for eliminating the iodoproteins more rapidly than normal Inasmuch as the patterns of intracellular localization in the cytoplasmic granules of the livers and spleens of the unresponsive rabbits were exactly the same as those observed previously with iodo-ovalbumin and certain azoproteins[8,10], it is clear that the presence of foreign antigenic material in cytoplasmic granules, while possibly a condition that precedes or is necessary for antibody formation[11], is not in itself a condition that leads inevitably to the production of measurable amounts of precipitating antibody

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* Scholar in Medical Science, The John and Mary R Markle Foundation

Of the many possible interpretations of these findings only one will be considered, namely, that the presence of antigen or haptenic fragments of degraded antigen may actually function to forestall antibody formation It is proposed that antibody formation is initiated as usual in a small number of susceptible cells whenever normal or unresponsive rabbits receive antigen However, the first molecules of antibody that are formed are likely to encounter cytoplasmic granules that contain residual antigen derived from the final injection, or (in the case of unresponsive rabbits) partially degraded haptenic residues remaining from previous injections of antigen Intracellular antigen–antibody reactions at appropriate loci could release the hydrolytic enzymes that are normally retained within the membranes of granules such as the lysosomes[12]

If the damage inflicted on essential structures by the reaction itself, or by the enzymes released or activated through the reaction, were sufficient to annihilate such cells, there would fail to be established a permanent line of cells that possessed the specific information necessary for antibody formation during the time when undegraded, antigenically potent antigen was still present in the rabbit Direct evidence is already at hand that the addition of antigen to tissue breis or to sera that contain specific antibody results in the activation of proteases[13–15] It is anticipated that a similar activation will follow the addition of antibody to sera, to homogenates of tissue, or to subcellular fractions that contain specific antigen Damage by proteases that are activated by immunological reactions has been suggested repeatedly over the years[14,16] as a reasonable basis for pathological changes at the tissue-level that occur in states of hypersensitivity The present suggestion is that under certain conditions such damage would not extend beyond individual cells in which antibody formation had been initiated The fact that induced immunological unresponsiveness is not permanent, unless antigen is continually administered[4], is attributed to the gradual loss (by degradation or by dilution) of haptenic residues from the potential antibody-forming cells, or to a fortuitous asymmetric distribution to daughter cells of the discrete granules that contain the antigen

Many more data are required before it will be possible to decide whether a number of phenomena already recorded in the literature are manifestations of some of the cellular events postulated here Insurmountable difficulties may confront attempts to assign microscopically visible effects unequivocally to macroscopically imposed causes, particularly when the effects that are judged as pertinent to the argument could be exceedingly rare events Nevertheless, it may be significant that degenerating, fragmented nuclei are found beside viable, primitive cells in the germinal centres of the lymphoid follicles, particularly during the natural immunization that accompanies bacterial infections[17] This paradoxical phenomenon is enhanced by immunization with antigens ordinarily regarded as innocuous Since a few molecules of antigen may be adequate to initiate antibody formation, while a relatively large amount of antigen may be required to ensure complete annihilation of antibody-forming cells, it is possible that the remarkable action of adjuvants (see ref 18) is to minimize the flood of antigen into the cytoplasmic granules of potential antibody-forming cells so that survival is more probable if the improbable events occur that culminate in antibody formation

It is noteworthy that application of the fluorescent antibody techniques of Coons to adult rabbits has shown that antibody is rarely detectable in cells that take up antigen, where devastating intracellular antigen–antibody reactions would be possible[19] Moreover, the antibody within germinal centres of stimulated lymph nodes is limited not only to individual cells, as in the medullary area, but occurs also "over an area of the follicle involving a number of cells in an indistinct way, often with a particulate distribution between the cells as well"[19] Antibody distributed in this manner may correspond to debris from cells which undertook antibody production while excessive amounts of antigen were still present in cytoplasmic particles On the other hand, antibody, but rarely antigen, is easily detected in members of the plasma cell series[19,20] The superficial injury that plasma cells are liable to suffer as a result of an extracellular antigen–antibody reaction, rather than causing cell death, may form what is frequently overlooked by many theorists, a concrete basis for the specific proliferative stimulus that must underlie the secondary response The mechanism which must be modified (or selected) in order for appreciable amounts of antibody to be formed appears to reside in cells that are highly sensitive to X-irradiation Once it is established, however, the antibody-forming mechanism is remarkably radioresistant[21] Although cells with different morphological properties appear to be involved at the beginning and at the end of the overall process of antibody formation, the striking qualitative differences of these cells with respect to radioresistance might depend upon the cellular locus of antigen–antibody reactions, rather than a fundamental change in cell type Perhaps death is an inevitable sequel to X-ray damage in cells that are also damaged by intracellular antigen–antibody reactions, while antibody-forming cells may survive X-irradiation in the absence of additional intracellular damage from antigen–antibody reactions Very recently, it was suggested[22] that X-irradiation destroys within minutes the ability of cells in lymphatic tissues to derive energy from nuclear phosphorylation reactions The intracellular antigen–antibody reactions postulated here might be expected in addition to derange alternative, cytoplasmic reactions that otherwise could have produced energy utilizable for survival and for eventual repair of the X-ray damage

Many previous theories of antibody formation have failed to provide adequate explanations for the fact that the secondary response is more intense than the primary response (for a discussion, see ref 19) On the other hand, certain versions of the 'selection theory', which currently enjoys much favour[23], appear to neglect the same fact viewed from the other direction, that the primary response is much less intense than the secondary response In the outline of the proposals presented here, the secondary response is assumed to depend upon a stimulation to proliferate that is selective for lines of cells that have inherited, or otherwise acquired, the specific information needed to synthesize antibody, which information was initially established in the few surviving cells that were modified as a result of the primary encounter with antigen The absence of a "suitable environment"[24] that was postulated to account for the failure of appreciable formation of antibody in new-born rabbits, even when competent cells were transferred from normal adult donors, may depend upon a possible deficiency of metabolites essential for survival and necessary to repair the intracellular damage caused by antigen–antibody reactions in individual cells where antibody formation was initiated

That transfer to new-born rabbits of lymphatic tissue from immunized donors is followed by formation of antibody[24] would depend upon the existence in the transferred tissue of cells in which the antibody-forming mechanism is free from potentially lethal intracellular antigen Natural tolerance towards self-materials and experimentally induced tolerance towards homografts, where many of the antigenic determinants that are involved still await chemical characterization, may also depend upon the selective destruction of cells in which auto-antibody formation is initiated The accidental survival of a few such cells, if followed by the passage of the antibody-forming mechanism into cells that are impervious to 'antigen', would explain the development of conditions of auto-immunization

The finding that iodoproteins appear to undergo the same fate in unresponsive rabbits as in normal rabbits has suggested simple mechanisms which might account for specific unresponsiveness and for a number of other immunological phenomena However, it is clear that the experiments have not clarified the ultimate problems of where and how the information necessary for the synthesis of a specific combining site is materialized, or whether this information exists in cells prior to a primary injection of the antigen.

A complete and more critical account of the experimental studies which form the basis of this discussion is being prepared for publication This work was supported by the United States Public Health Research Grants *E*-1296 and *E*-1296(*C*) We are indebted to Dr Joshua L Edwards for many informative and stimulating discussions, and for making available the opportunities and facilities that made the studies possible One of us (F R F) has received support from U S Public Health Service *RG*-4801 (*C2S*1) [May 13

[1] Hanan, R , and Oyama, J , *J Immunol* , **73**, 49 (1954)
[2] Cinader, B , and Dubert, J M , *Proc Roy Soc* , B, **146**, 18 (1956)
[3] Cinader, B , Pearce, J H , and Carter, B G , *Nature*, **181**, 1208 (1958)
[4] Smith, R T , *Fed Proc* , **17**, 535 (1958)
[5] Dixon, F J , and Maurer, P H , *J Exp Med* , **101**, 245 (1955)
[6] Eisen, H N , *Fed Proc* , **10**, 179 (1951)
[7] Boyd, W C , "Fundamentals of Immunology", 79 (Interscience Publishers, New York, 1956)
[8] Haurowitz, F , and Crampton, C F , *J Immunol* , **68**, 73 (1952)
[9] Crampton, C F , Rodeheaver, J L , and Frankel, F R , *Fed Proc* , **18**, 208 (1959)
[10] Crampton, C F , Reller, H H , and Haurowitz, F , *Proc Soc Exp Biol Med* , **80**, 448 (1952)
[11] Haurowitz, F , *Biol Rev* , **27**, 247 (1952)
[12] de Duve, C , "Symposia of the Society for Experimental Biology", No 10, 50 (1957)
[13] Ungar, G , *Lancet*, 1, 708 (1947)
[14] Geiger, W B , *J Immunol* , **68**, 11 (1952)
[15] Lepow, I H , *et al* , *J Immunol* , **73**, 146 (1954)
[16] Bronfenbrenner, J , *J Exp Med* , **21**, 221 (1915)
[17] Yoffey, J M , and Courtice, F C , "Lymphatics, Lymph and Lymphoid Tissue", 39 (Harvard Univ Press, 1956)
[18] White, R G , Coons, A H , and Connolly, J M , *J Exp Med* , **102**, 83 (1955)
[19] Leduc, E H , Coons, A , and Connolly, J M , *J Exp Med* , **102**, 61 (1955)
[20] Coons, A H , Leduc, E H , and Kaplan, M H , *J Exp Med* , **93**, 173 (1951)
[21] Dixon, F J , Talmage, D W , and Maurer, P H , *J Immunol* , **68**, 693 (1952)
[22] Ord, M G , and Stocken, L A , *Nature*, **182**, 1787 (1958)
[23] Burnet, F M , *Austral J Sci* , **20**, 67 (1957) Talmage, D W , *Ann Rev Med* , **8**, 239 (1957) Nossal, G J V , and Lederberg, J , *Nature*, **181**, 1419 (1958) White, R G , *ibid* , **182**, 1383 (1958). Lederberg, J , quoted in *Scope Weekly*, **3**, No 49, 1 (1958)
[24] Dixon, F J , and Weigle, W O , *J Exp Med* , **105**, 75 (1957)

HYDROGENATION OF LIPIDS BY RUMEN PROTOZOA

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IT has been observed by several workers that dietary unsaturated fats are modified in the rumen by hydrogenation Shorland, Weenink and Johns[1] found that the fatty acid composition of ingested plant material was considerably changed by rumen contents In particular, the high content of linolenic acid was markedly reduced, being converted mainly to stearic acid This work was confirmed by Shorland, Weenink, Johns and McDonald[2] when they demonstrated that rumen contents *in vitro* could hydrogenate oleic, linoleic and linolenic acids Other studies on hydrogenation include those by Hoflund, Holmberg and Sellmann[3] using cows fed linolenic acid, Reiser and Reddy[4] with goats fed on a diet supplemented with unsaturated oils, and more recently Garton, Hobson and Lough[5] with sheep The type of micro-organism responsible for the hydrogenating activity has not been determined in these studies

It has been observed that some species of protozoa are able to ingest chloroplasts[6] Since chloroplasts are rich in lipid material, particularly unsaturated fatty acids, it was thought likely that these ciliates may be responsible for at least some of the hydrogenation occurring in the rumen

Rumen contents were collected from a rumen-fistulated cow fed on fresh red clover (*Trifolium pratense*) and the protozoa allowed to settle by gravity Microscopic examination of the protozoa showed a mixed population of holotrichs and oligotrichs, the latter group being mainly Epidinia Washed suspensions of the ciliates were prepared by the procedure described by Oxford[6] using an acetate–bicarbonate–phosphate buffer containing penicillin and neomycin After washing to free them of bacteria, the protozoa were suspended in the buffer with antibiotics to which the substrate and clover starch were added The flasks were incubated under carbon dioxide at 38° or 4° After overnight incubation, the lipid material was extracted from the solution by acidifying with hydrochloric acid and extracting with petroleum ether The fatty acids were isolated by the usual methods and their iodine numbers calculated by the Hanus procedure Under these

Table 1 Hydrogenation of Sodium Linoleate and Linseed Oil by a Suspension of Rumen Protozoa

Incubation temperature	Substrate	Iodine number
4°	Sodium linoleate	162 6
38°	Sodium linoleate	101 2
4°	Linseed oil	160 0
38°	Linseed oil	120 0

conditions, hydrogenation of both linoleic acid and linseed oil was found (Table 1)

The hydrogenation of chloroplast fat was next examined by incubating protozoa with chloroplasts A suspension of chloroplasts was prepared by grinding freshly picked red clover leaves in an end-runner mill with a sucrose–phosphate buffer solution[7] After removing the fibrous material by filtration through muslin, the filtrate was centrifuged at 100*g* for 10 min to remove large plant particles and the supernatant centrifuged at 1,500*g* for 20 min to sediment chloroplasts The chloroplasts were suspended in the acetate–bicarbonate–phosphate buffer plus antibiotics and equal volumes added to two 100-ml conical flasks containing washed protozoa suspensions, one of which had been placed in a boiling water-bath to destroy enzyme activity The flasks were flushed with carbon dioxide and then incubated at 38° C , provision being made for the release of gas from the flasks

After incubating overnight, the boiled control sample was still green in colour, but the test sample was coloured yellow, indicating breakdown of chlorophyll The samples were freeze-dried and the lipids extracted by boiling with diethyl ether The ether solutions were evaporated to dryness, taken up in petroleum ether and the solvent removed *in vacuo* The lipids were saponified and fractionated into water-soluble, non-saponifiable and fatty acid fractions The fatty acids were converted to the methyl esters and analysed by gas-liquid chromatography Considerable differences were noted between the test and control sample fatty acids (Table 2)

The composition of the C^{18} acids in the boiled control sample is typical of red clover chloroplast lipid (Weenink, R O , personal communication)

Table 2 Comparisons between C^{18} Fatty Acid Composition of Chloroplast Lipids incubated with Live or Dead Rumen Protozoa

Fatty acids weight per cent

Sample + Chloroplasts	Saturated	Unsaturated		
		mon-	di-	tri-ene
Live protozoa	17 5	10 6	27 6	44 3
Boiled protozoa	10 7	16 2	2 8	70 3
Difference	+6 8	−5 6	+24 8	−26 0

There has been considerable conversion of triene acid to diene acid and monoene to stearic acid Only a slight conversion of diene to monoene seems to have occurred This is rather surprising since it was shown above that protozoa could hydrogenate linoleic acid Reiser[8] suggested that rumen contents convert linolenic acid merely to linoleic acid although Shorland *et al* [1] showed further hydrogenation of linoleic acid to monoene and saturated acids Since a considerable amount of linolenic acid still remained in these protozoa experiments, there must have been an excess of unsaturated lipid present and it may be possible that the enzyme or enzymes responsible for hydrogenation show some degree of specificity and attack the triene and monoene acids preferentially Since little is known about the mechanisms of enzymic hydrogenation, this must remain speculative at the moment

The non-saponifiable material from both samples was yellow in colour, had similar intensities and spectra typical of a carotene–xanthophyll mixture In spite of the carotene being highly unsaturated, little hydrogenation of the pigment has occurred This is in agreement with the observations made by Shorland, Weenink, Johns and McDonald[2]

In spite of attempts to wash the protozoa clean of external bacteria, some bacteria were undoubtedly present inside the ciliates Their role in hydrogenation is difficult to assess , but it seems likely that they were not present in great enough numbers to have much effect Preliminary experiments using washed suspensions of rumen bacteria suggest that bacteria do not contribute a great deal to the hydrogenation occurring in the rumen It is interesting to speculate whether fluctuations in the population of protozoa could be correlated with the seasonal variation in iodine numbers of milk fat noted in New Zealand[9]

Further studies on the role of bacteria and individual species of protozoa in lipid metabolism are in progress I would like to thank Miss J Michael for technical assistance, and Dr J C Hawke and Miss J Cook, of the Fats Research Laboratory, Wellington, for the gas–liquid chromatography data

[1] Shorland, F B , Weenink, R O , and Johns, A T , *Nature*, **175**, 1129 (1955)

[2] Shorland, F B , Weenink, R O , Johns, A T , and McDonald, I R C , *Biochem J* , **67**, 328 (1957)

[3] Hoflund, S , Holmberg, J , and Sellmann, G , *Cornell Vet* , **45**, 254 (1955)

[4] Reiser, R , and Reddy, H G R , *J Amer Oil Chem Soc* , **33**, 155 (1956)

[5] Garton, G A , Hobson, P N , and Lough, A K , *Nature*, **182**, 1511 (1958)

[6] Oxford, A E , *N Z J Agric Res* , **1**, 809 (1958)

[7] Crombie, W M , *J Exp Bot* , **9**, 254 (1958)

[8] Reiser, R , *Fed Proc* , **10**, 236 (1951)

[9] Mayhead, J W , and Barnicoat, C R , *J Dairy Res* , **23**, 238 (1956).

FORMATION OF THE PORPHYRIN RING

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IT is generally agreed that the naturally occurring porphyrins arise through the condensation of four molecules of porphobilinogen (I) However, it has proved very difficult to formulate a sequence of reactions leading uniquely from porphobilinogen to the type III and type I porphyrins Several years before any of the reactions leading to porphyrin formation were recognized, Turner[1] had realized that the essential clue to the understanding of the cyclization of the porphyrin ring was to be found in the behaviour of tripyrrylmethanes, established by Corwin *et al* [2,3] Shemin, Russell and Abramsky[4] and Bogorad and Granick[5] have elaborated these ideas In the course of the isolation of isotopically labelled hæmin from duck red blood cells[6], Shemin and I (unpublished work) encountered a colourless, stable, intensely radioactive, protein-bound material, which was thought to be a polypyrrole On the strength of this finding, compounds containing several pyrrole rings were considered as possible intermediates in the condensation of porphobilinogen (I) to the uroporphyrinogens (IV, V), the parent substances of the porphyrins If Turner's tripyrryl-methane hypothesis is coupled to the idea that the rearrangements leading to the type III porphyrins occur within a single large molecule, a mechanism for porphyrin formation emerges which not only satisfies all the chemical requirements put forth below but also provides a rational interpretation of the results of Bogorad's[7-9] elegant enzymatic studies This formulation has the virtue that it reveals the unique structure of the type III porphyrins to be a necessary consequence of the chemical structure of the key intermediate, a cyclic octapyrrole (III), in their formation

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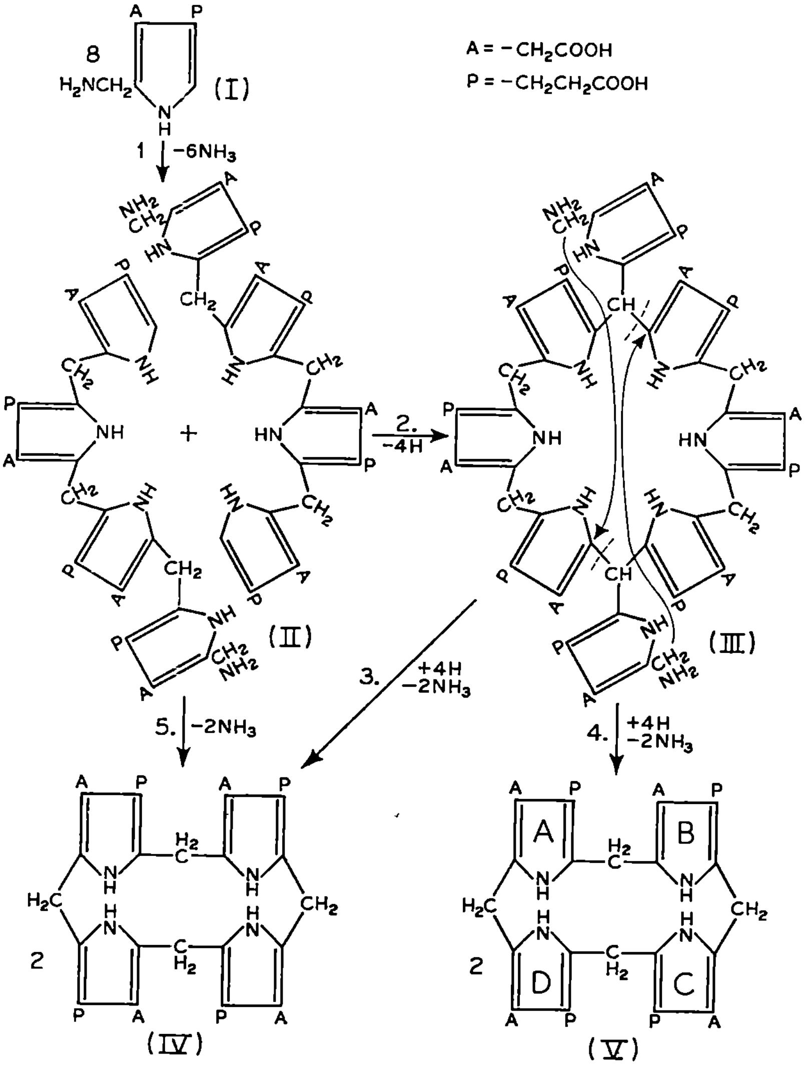

The primary requirement to be fulfilled by the octapyrrole hypothesis is that it must lead to the formation of only type III and type I uroporphyrinogens (V and IV respectively) since type II and IV isomers are not formed enzymatically[7,8], and type II and IV porphyrins do not occur in Nature Furthermore, the isomeric specificity must be independent of the action of enzymes and reside in the chemical nature of the reaction since, in the presence of hydrochloric acid, (I) is converted largely to (V), with the formation of lesser amounts of (IV)[10,11] These conditions are met by reactions 4, 5 and 3 In addition, the octapyrrole hypothesis fulfils all the following subsidiary requirements all four pyrrole rings of the porphyrin must arise from a single common precursor (I), in agreement with the very exact equivalence of the isotope concentrations in the neutral and acidic pyrroles of hæmin formed from isotopically labelled precursors[6,12,13] All of (I) consumed in the reaction must be converted to porphyrin without the obligate formation of pyrrolic by-products, in agreement with the more than 90 per cent[14] or 80 per cent[8] conversion of (I) to porphyrins achieved enzymatically, or the 77 5 per cent conversion achieved in the presence of hydrochloric acid[11] All four of the methene bridge carbon atoms must be derived from the aminomethyl side-chain of (I), in agreement with the isotope data[6]

Most of the schemes of porphyrin formation hitherto proposed (refs 4, 5, 11, 17, and reviewed in refs 15, 16) do not account for the formation of porphyrins I and III uncontaminated by other isomers, nor can they account for the very high yields of uroporphyrin-III formed from porphobilinogen

Formaldehyde may be a product of the enzymatic and non-enzymatic conversion of (I) to porphyrin[4] This would constitute strong evidence against the present proposal only if the formaldehyde were shown to arise in stoichiometric amounts from the aminomethyl group of (I)

The octapyrrole hypothesis may be stated in conjunction with Bogorad's recent enzymatic work[7-9] He finds[7] that the enzyme porphobilinogen deaminase converts (I) to (IV) However, since a second enzyme named 'uroporphyrinogen isomerase' has as its sole substrate a product (different from IV) of the action of porphobilinogen deaminase on (I) (ref 8), it appears necessary to postulate that an as yet undetected colourless compound is the primary product of the action of porphobilinogen deaminase The structure of this material must be such that it is easily convertible, either spontaneously or under the further action of porphobilinogen deaminase, to (IV) (reaction 5) The suggestion is advanced that this unknown compound is the linear tetrapyrrole (II), and that the primary action of porphobilinogen deaminase is to convert porphobilinogen (I) to a linear tetrapyrrole (II) (reaction 1)

The enzyme 'uroporphyrinogen isomerase' acts to yield uroporphyrinogen-III (V) as its first detectable product[8,9] The suggestion is advanced that the function of this enzyme is to condense two molecules of (II) (reaction 2), thus introducing the two tripyrrylmethane structures of (III), and the primary product of its action is the cyclic octapyrrole (III) The cyclic octapyrrole is considered to undergo re-arrangement, either spontaneously or under the further action of the 'uroporphyrinogen isomerase' preparation, to yield two molecules of uroporphyrinogen-III (V) (reaction 4) (An analogous reaction leading to (IV) (reaction 3) will be shown to be less probable)

The overall result of this sequence of reactions is the interchange of the pyrrole moieties destined to form rings *D* of the porphyrins between two tetrapyrroles, with a consequent reversal of the position of the rings *D*, relative to the other pyrrole rings of the tetrapyrroles

An approximate model of (III) demonstrated that reactions 4 and 3 can take place only if the two asymmetric tripyrrylmethane carbon atoms are of the same configuration, and that if this is so the two 'branch' pyrroles must lie on the same side of the plane of the major ring The entire structure can be bent so that the 'branch' pyrroles pass each other and their aminomethyl groups are brought into apposition with the alpha positions of the pyrroles opposite in the ring The simultaneous attack of both aminomethyl groups on the appropriate pyrrole alpha carbon atoms (indicated by arrows in the figure) with consequent scission (indicated by dotted lines) of both tripyrrylmethane moieties leads to rearrangement of (III) to two molecules of (V) (reaction 4) The preferential formation of uroporphyrinogen-III (V) would appear to be a consequence of interactions between the carboxyethyl side-chains of the 'branch' pyrroles with the side-chains of the adjacent pyrroles of the major ring The model shows these to lie in close proximity

Reactions analogous to the foregoing have been described[3,18]

A formulation similar to the foregoing but involving only four pyrroles is ruled out because it was not possible to construct a model of a ring with only three pyrroles

These considerations lead to the prediction that the final ring-closure leading to the porphyrins should occur between rings *A* and *D* Bonnett *et al* [19], on the basis of structural considerations, feel that ring closure of the chromophore of vitamin B_{12} must also occur between rings *A* and *D*, the biogenesis of this molecule is certainly similar to that of the porphyrins[19-21]

Robinson[22] suggested that the initial step in the formation of the type III porphyrin is attack by the aminomethyl group of a porphobilinogen molecule (corresponding to ring *D* of the porphyrin) at the $C_{(2)}$ of a second molecule (corresponding to porphyrin ring *A*) The aminomethyl group, initially at $C_{(2)}$, is regarded as migrating to $C_{(5)}$ of the ring Repetition of the process leads to type III porphyrin, the final ring closure being facile Bullock *et al* [23] have put forward an essentially similar idea, but differing in that the initial attack is thought to be by the aminomethyl group of a porphobilinogen molecule destined to form porphyrin ring *A*, on $C_{(2)}$ of a second molecule destined to form ring *D* These latter authors invoke carbonium ions to explain the migration of the alpha-substituents Either of these chemically elegant postulations will explain the preferential formation of type III porphyrins, and, in addition, fulfil the requirements for the reaction enumerated above However, they are not consistent with the known formation of uroporphyrinogen-I from an intermediate in the enzymatic synthesis of uroporphyrinogen III Further, since the initial, rather than the final, reaction occurs between porphyrin rings *A* and *D*, these postulations cannot provide a facile explanation of the formation of vitamin B_{12}

[1] *J Lab Clin Med* , **26**, 323 (1940)
[2] Corwin and Andrews, *J Amer Chem Soc* , **59**, 1973 (1937)
[3] Andrews, Corwin and Sharp, *J Amer Chem Soc* , **72**, 491 (1950)
[4] *J Biol Chem* , **215**, 613 (1955)
[5] *Proc U S Nat Acad Sci* , **39**, 1176 (1953)
[6] Wittenberg and Shemin, *J Biol Chem* , **185**, 103 (1950)
[7] *J Biol Chem* , **233**, 501 (1958)
[8] *J Biol Chem* , **233**, 510 (1958)
[9] *J Biol Chem* , **233**, 516 (1958)
[10] Waldenström and Vahlquist, *Z physiol Chem* , **260**, 189 (1939)
[11] Cookson and Rimington, *Biochem J* , **57**, 476 (1954)
[12] Wittenberg and Shemin, *J Biol Chem* , **178**, 47 (1949)
[13] Muir and Neuberger, *Biochem J* , **45**, 163 (1949)
[14] Dresel and Falk, *Biochem J* , **63**, 80 (1956)
[15] Maitland, *Quart Rev Chem Soc* , **4**, 45 (1950)
[16] Rimington, "Ann Rev Biochem ," **26**, 561 (1957)
[17] Bogorad, in "Conference on Hemoglobin", U S Nat Acad Sci — Nat Res Council, Washington, D C , 1958, p 74
[18] Fisher and Rothhaas, *Ann Chem* , **484**, 85 (1930)
[19] Bonnett, Cannon, Johnson, Sutherland, Todd and Smith, *Nature*, **176**, 328 (1955)
[20] Shemin, Corcoran, Rosemblum and Miller, *Science*, **124**, 272 (1956)
[21] Corcoran and Shemin, *Biochim Biophys Acta*, **25**, 661 (1957)
[22] Robinson, "The Structural Relations of Natural Products," p 24 (Oxford, 1955)
[23] Bullock, Johnson, Markham and Shaw, *J Chem Soc* , 1430 (1958)

SYNTHESIS OF DIPICOLINIC ACID FROM αε-DIKETOPIMELIC ACID

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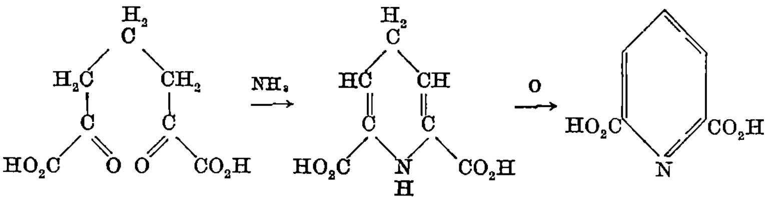
CALCIUM dipicolinate is a constituent of resting spores of *Bacillus* species and is excreted during spore germination[1] It is not found as a constituent of non-sporulating vegetative cells but is synthesized during spore formation Vegetative cells and spores of *Bacillus* species contain αε-diaminopimelic acid which, on removal of one amino-group, cyclization and oxidation, would give rise to dipicolinic acid The L-amino-acid oxidase of *Neurospora crassa* oxidizes *meso* diaminopimelic acid with the production of ammonia equivalent to the removal of one amino-group of the amino-acid[2,3] The product has no free amino- or keto-groups Work[3,4] suggests that the α-keto-ε-aminopimelic acid formed may cyclize immediately to form a six-membered ring compound If this is so, then the product without oxidation could be a reduced form of dipicolinic acid Evidence of the conversion of diaminopimelic acid to dipicolinic acid in the presence of sporulating cells of *Bacillus cereus* var *mycoides* was obtained by Perry and

Foster[5], but the efficiency of the reaction was low In the present work, αε-diketopimelic acid has been investigated as a possible intermediate in the biosynthesis of dipicolinic acid by bacteria The diketo-acid was prepared by the method of Blaise and Gault[6]

When disintegrated cells of a laboratory strain of *Bacillus cereus* were incubated in air with αε-diketopimelic acid, a slow oxidation occurred (Q_{O_2} *c* 1) and there was a decrease in free ammonia as determined by the Conway method The rate of oxidation was markedly increased (Q_{O_2} *c* 7) by the addition of ammonium chloride The reaction was allowed to proceed in Warburg flasks in 100 m*M* sodium potassium phosphate buffer, *p*H 7 3, with 10 m*M* diketopimelic acid and 20 m*M* ammonium chloride The volume of the reaction mixture was 2 5 ml and each flask also contained 40 mgm (dry weight) of freshly reaped, washed disintegrated cells from 12-hr strongly sporulating cultures in potato extract medium[7] The ultra-violet absorption spectrum of the reaction mixture showed peaks at 2700 and 2775 A , thus resembling dipicolinic acid It seemed possible that the reaction sequence was as follows



I II III

In these experiments, the production of ultra-violet light-absorbing material was measured, after protein precipitation, by taking difference spectra, that is, the difference in absorbency between reaction mixtures with and without ammonia The addition of diphosphopyridine nucleotide to the reaction mixtures did not improve the rate of oxidation of the diketo acid The reaction proceeded with the fixation of 60–80 per cent of the calculated amount of ammonia required for the complete conversion of I to II and the oxygen uptake was roughly 80 per cent of that required for the formation of one double bond, that is, for conversion of II to III The observed increase in the intensity of the ultra-violet absorption spectrum, however, approached only 50 per cent of that required for the complete conversion of I to III The highest rates of oxidation of the keto acid occurred in the presence of an ammonium salt as amino donor Glucosamine, glutamic acid and L-alanine were tested as amino donors they gave slow and less complete oxidation which was not improved by the addition of pyridoxal phosphate Glutamine, however, gave higher initial rates of oxidation than did ammonium chloride The very low Q_{O_2} values obtained for oxidation of diketopimelic acid when no ammonium chloride was added suggested that the oxidizable substrate was, in fact, a reaction product of the keto acid and ammonium ion The oxidative system was remarkably heat-stable compared with that obtained with unheated extract, the rate of oxygen uptake was actually increased in the presence of extract previously heated for 10 min at 100° and centrifuged to remove precipitated material Assuming this oxidative system is required by living cells to synthesize dipicolinate from αε-diketopimelic acid + ammonium ion it would be expected that such a system and/or the substrate are absent from vegetative non-sporulating cells When a comparison was made of the oxidative activity of cell homogenates of asporogenous and sporogenous strains of *Bacillus megaterium*, the asporogenous strain was found to give a higher rate of oxygen uptake than the sporogenous strain In another experiment, disintegrated vegetative cells of *Bacillus cereus* gave a higher rate of oxygen uptake than disintegrated sporulating cells Finally, an extract of disintegrated cells of *Escherichia coli* was examined and was found to be as active in the system as an extract of disintegrated cells of *Bacillus cereus*

When a solution of the calcium salt of diketopimelic acid and ammonium salt was incubated with buffer, *p*H 7 1, no oxygen uptake occurred However, ammonia was fixed and an ultra-violet absorption spectrum developed which was similar to but less intense than that obtained under similar conditions in the presence of cell extract A comparison of the rates of production of ultra-violet absorbing material in the presence and absence of cell extract is shown in Fig 1 After 4 hr at 37° C the yields of product for reactions in the presence and absence of extract were about 44 and 21 per cent of theoretical, respectively, based on the molar extinction coefficient of calcium dipicolinate at 2700 A Higher yields were obtained if incubation was continued for 24 hr When the reaction mixture in which ultra-violet absorbing material had been produced in the absence of cell extract was re-incubated with added cell extract, no oxygen uptake occurred The possibility existed that, in the absence of cell extract, a dihydropyridine-2 6-dicarboxylic acid was produced which gave a similar but less intense ultra-violet absorption spectrum than dipicolinate Isolation of the product was therefore attempted

αε-Diketopimelic acid (40 mgm) was dissolved in water (8 ml) and calcium carbonate (21 mgm) added to form the neutral calcium salt An equal volume

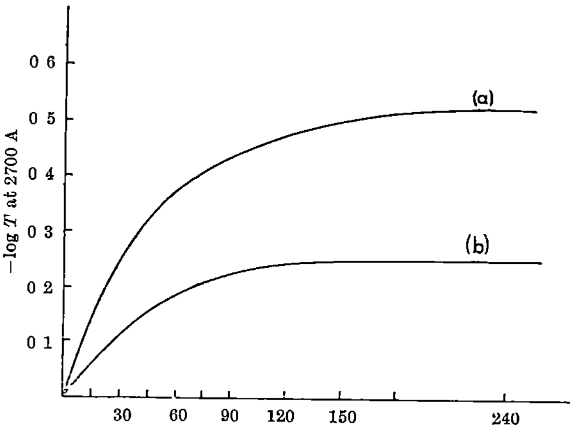


Fig 1 Rate of formation of material absorbing at 2700 A from diketopimelic acid and ammonium salt (*a*) Reaction mixture (2 ml) contained diketo acid (5 mgm), calcium carbonate (2 5 mgm), ammonium acetate (8 mgm) and heated centrifuged extract from disintegrated vegetative cells of *Bacillus cereus* (20 mgm dry wt) Control contained no diketo acid (*b*) as for (*a*) but without cell extract Control contained no ammonium acetate Samples (0 1 ml) removed at intervals after incubation at 37° C on a rotary shaker The absorption of the diluted sample (1 30) was measured in a 'Unicam' quartz spectrophotometer (*S P* 500) using the appropriate control as blank

of 0 1 M ammonium acetate solution was added and the resulting solution (pH 7 1) was incubated at 37° C for 24 hr The incubated solution was freeze-dried, which removed most of the excess ammonium acetate The product was dissolved in water (1 ml) and treated with ethanol (3 ml) The precipitate was recovered by centrifugation, dried and shaken with a small volume of 0 05 M calcium chloride solution The insoluble fraction was recovered and dissolved in the minimum volume of hot water On cooling, crystallization occurred The insoluble material was recrystallized from hot water The crystals were isolated and dried *in vacuo* at 60° C over phosphorus pentoxide Yield approximately 6 mgm Similar material was isolated from reaction mixtures containing cell extract In both cases the product was calcium dipicolinate according to the following criteria (1) appearance of the crystals , (2) extinction coefficients at 2700 and 2775 A , (3) the infra-red spectra of both products which agreed exactly with that of natural calcium dipicolinate , (4) paper chromatography using Whatman paper (No 1 or 4) and butanol/acetic acid/water (4 1 5 v/v, upper phase) as solvent The spots corresponding to the products and authentic calcium dipicolinate were visible when the dried paper was viewed with a source of ultra-violet light ('Chromalite' lamp) and had the same R_F value When the paper was sprayed with a solution containing ferrous ammonium sulphate (0 1 per cent w/v) and ascorbic acid (0 1 per cent w/v) in 0 5 M acetate buffer, pH 5 5 (ref 8), the spots turned pink

The formation of dipicolinate in the absence of oxygen uptake can only be explained in terms of an oxidation-reduction reaction occurring between the products of the reaction of diketopimelic acid with ammonia, and perhaps diketopimelic acid Identification of products other than dipicolinate has not been attempted , but paper chromatography of reaction mixtures showed that a number of compounds is produced When the effect of oxidizing agents on the reaction was studied it was found that quinone had an effect similar to that of cell extract on the rate of production and final yield of ultra-violet light absorbing product Fig 2 shows the rate of production of material absorbing at 2700 A in the presence and absence of quinone The absorbency values were affected by the formation of hydroquinone, but increased formation of dipicolinate in the presence of quinone was confirmed by paper chromatography It is possible that the oxidative system in bacterial cells acts in a similar way to quinone and the reduced system is then oxidized directly or indirectly by atmospheric oxygen

Attempts to demonstrate diketopimelic acid as a constituent of sporulating cells of *Bacillus cereus* were unsuccessful In these experiments, deproteinized cell extracts were treated with 2 4-dinitrophenylhydrazine and the keto-acid derivatives were extracted with ethyl acetate and chromatographed on paper[9] Comparison spots of the 2 4-dinitrophenylhydrazones of α-ketoglutaric, oxaloacetic, pyruvic and αε-diketopimelic acids and of acetone were run on the same paper The chromatogram showed derivatives of pyruvic acid and acetone to be present but no diketopimelic acid could be detected in 120 mgm (dry weight) of cells However, it was found that when diketopimelic acid was added to cell suspensions which were then disintegrated, treated with reagent and chromatographed, the dinitrophenylhydrazone of this keto acid could not be detected A negative result was probably due to the rapid reaction of the keto acid with endogenous ammonia when the cells were disrupted

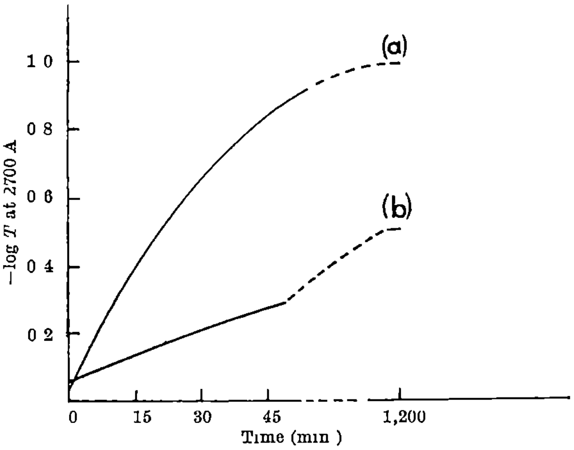


Fig 2 Effect of quinone on the formation of dipicolinic acid from diketopimelic acid and ammonium salt (*a*) Reaction mixture (1 ml) contained diketo acid (2 mgm), calcium carbonate (1 mgm), ammonium acetate (4 mgm) and quinone (0 1 ml sat aq solution) Control solution contained no diketo acid (*b*) As for (*a*) but without quinone Solutions incubated at 37° C and samples treated as in Fig 1

Attempts to implicate αε-diketopimelic acid as a precursor of αε-diaminopimelic acid in bacterial cells were unsuccessful Reaction mixtures after incubation of cell homogenate with keto acid and either ammonium chloride, glutamic acid, glutamine or aspartic acid were tested for the presence of diaminopimelic acid using the solvent system of Rhuland *et al* [10] Unheated cell homogenates were tested in these experiments and pyridoxal phosphate was added No diaminopimelic acid was detected in samples of reaction mixture initially containing 130 μgm of the keto acid

In an interesting article on the pyridine ring and the problem of its biosynthesis, Grimshaw and Marion[11] have suggested that the pyridine ring might be built directly from smaller units arising from alanine and glycine or possibly from non-nitrogenous precursors and ammonia Martin and Foster[12] have reported two possible pathways of dipicolinate synthesis in *Bacillus megaterium* involving either pyruvate and aspartate or alanine and oxaloacetate The experiments reported here are of interest in this connexion, and we consider that even though diketopimelic acid has not been demonstrated as a cell constituent, its reactions with ammonia in the presence and absence of cell extract suggest some interesting possibilities

We wish to thank Mr S Lovett for synthesizing αε-diketopimelic acid and Dr K P Norris for infra-red spectrophotometry We are grateful to Dr D H Herbert, Mr E O Powell and Major L H Kent for useful suggestions and discussion

[1] Powell, J F , *Biochem J* , **54**, 210 (1953) , *J App Bact* , **20**, 349 (1957)
[2] Burton, K , *Biochem J* , **50**, 258 (1951)
[3] Work, E , *Biochem J* , **49**, 17 (1951)
[4] Work, E , *Biochim Biophys Acta*, **17**, 410 (1955)
[5] Perry, J J , and Foster, J W , *J Bact* , **69**, 337 (1955)
[6] Blaise, E E , and Gault, H , *Bull Soc Chim* , Serie 4, **1**, 75 (1907)
[7] Powell, J F , and Strange, R E , *Biochem J* , **63**, 661 (1956)
[8] Jannsen, F W , Lund, A J , and Anderson, L E , *Science*, **127**, 26 (1958)
[9] El Hawary, M F S , and Thompson, R H S , *Biochem J* , **53**, 340 (1953)
[10] Rhuland, L E , Work, E , Denham, R F , and Hoare, D S , *J Amer Chem Soc* , **77**, 4844 (1955)
[11] Grimshaw, J , and Marion, L , *Nature*, **181**, 112 (1958)
[12] Martin, H H , and Foster, J W , *J Bact* , **76**, 167 (1958)

HIGH-RESOLUTION FIBRE OPTICS USING SUB-MICRON MULTIPLE FIBRES

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In various image transmitting applications of fibre optics[1,2] using the light conduction property of fibres because of total internal reflexions, it is desired that the fibres have a high light transmission, complete optical insulation and diameter as small as possible. The information density in a perfectly insulated fibre bundle is dependent only on the fibre diameter, which has been limited by mechanical properties of the fibres and the basic diffraction phenomenon. This latter limitation, due to diffraction, has not been investigated in the past[3,4], and it had been believed that only fibres larger than 10–20 wave-lengths in diameter are capable of conducting energy. For smaller diameters, it was believed that the energy escapes from the fibre wall due to the diffracted wave striking at angles less than critical incidence.

This is found not to be true for circular cross-section straight fibres down to approximately two wave-lengths in diameter. Fibres as small as 0·75 μ in diameter have been drawn using the newly developed technique of 'multiple fibres', and found to give acceptable light transmission. Whereas diffraction effects occur for fibres of smaller diameter, it has been found that the effective numerical aperture of the emergent diffracted light cone from a straight fibre of diameter greater than two wave-lengths of light is not substantially in excess of the numerical aperture of the lens system required to resolve clearly the fibres at the image pickup end. On the other hand, all the emergent flux is received when a photodetector or photographic plate is placed in contact with the emergent end. Thus high resolution, as well as high light efficiency, is achievable using the more recent techniques in fibre optics.

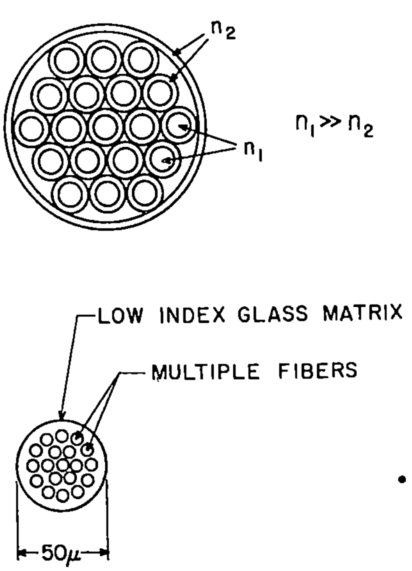
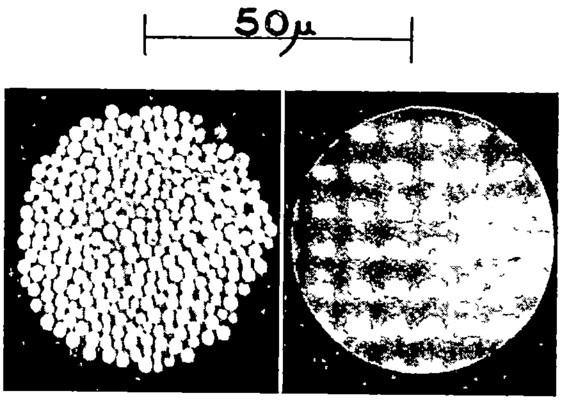


Fig. 1 Illustrating the method of drawing multiple fibres



Multiple fibre Dynamic image

Fig 2 Photomicrograph of grid object through a 50μ overall diameter multiple fibre consisting of approximately 275 fibres of 2·5μ average diameter

A method for drawing high refractive index fibres coated with a glass of low refractive index consists, essentially, of placing a high-index rod in a low-index tube and pulling the assembly down to a fibre on a continuously rotating drum[5]. Fibres down to 25μ diameter with a coating thickness of 0·5–1μ have been drawn in nominal infinite lengths. In addition to optically insulating the fibre, the coating, also, eliminates surface absorption or scattering losses. A 7-ft.-long glass-coated glass fibre is found to transmit an average of 20 per cent in the visible spectrum and nearly 50 per cent in the yellow-green region. However, such fibres become very difficult to handle mechanically in diameters much smaller than 25μ.

A new type of 'multiple fibre' consisting of a large number of fibres of high refractive index in an insulating matrix of low refractive index has been developed. They have the mechanical strength of large fibres and resolution yield of much smaller fibres. Fig. 1 shows a method for drawing multiple fibres. A large number of high refractive index rods are inserted in low refractive index tubes and the entire bundle is placed in a larger tube of compatible glass. This unit is then drawn into a fibre on a continuously rotating drum. The cross-section of resultant fibres is also illustrated in Fig. 1. The ratio of the parent rod to tube thickness, etc., is maintained in the fibre form. Multiple fibres down to 50μ overall diameter, consisting of as many as 275 fibres of approximately 2·5μ diameter, have been drawn by this method. A high-information density is thus achievable. The mechanical advantages of manipulating and fusing fibres down to a few microns in diameter by this technique are obvious.

Fig. 2 shows a multiple fibre of overall diameter 50μ, with average fibre diameter of 2·5μ. A dynamic picture of a grid test object through this multiple fibre is also shown in Fig. 2. Limiting static resolution of up to 200 lines/mm. has been measured in such an assembly of multiple fibres. As is indicated by further diffraction studies, the resolution obtained thus far is not the upper limit for the fibre optical systems

In order to study the optical properties and diffraction effects in smaller fibres, multiple fibres ranging between 0 75 and 20μ in diameter have been drawn This was achieved simply by choosing parent rods and tubes of different diameters A multiple fibre was placed on a microscope in which both the numerical apertures of the condenser and the objective could be varied along with the wave-length of light Fig 3 illustrates this apparatus diagrammatically The image of the multiple fibre is formed on a photodetector for the purposes of photometry of fibres of various diameters Interference filters were introduced in the path; thus different ratios of wave-length of light to fibre diameter are obtained From elementary considerations, it is clear that due to the diffraction by the fibres, as the objective N A is decreased, the photodetector would receive less flux per unit area from fibres of smaller diameters

Multiple fibres ranging from 0 75μ to 8μ diameter, 0 2 in long, were thus studied on the above-mentioned system Two wave-lengths peaked at 386 mμ and 663 mμ with half band-width of 125 A were used The condenser numerical aperture was varied from 0 4 to 0 8 and the objective N A was varied from 0 3 to 1 33 Within this range of N A and wave-lengths, for fibres above 0 75μ diameter, no measurable difference in flux density was observed For smaller N A of the objective, however, one might expect the effects to show up On the other hand, for such small objective N A the fibres fall close to the resolution limit of the system used for image pickup Fig 4 shows various diameter multiple fibres that were examined in this manner and a 0 75μ diameter fibre is indicated by an arrow In Fig 4*a*, it should be noticed that some fibre separations are of the order of one wave-length, which is the desired thickness, in order to prevent light leakage between neighbouring fibres ($d > \lambda$) due to frustrated total reflexion[5] Very small quantities of light were observed between adjacent fibres This is attributable primarily to the diffraction effects in the microscope objective and perhaps to a lesser degree to light scattering by the low-index medium that may experience large amounts of stress In Fig 4*b* the fibre separation is not observable because the low-index coating falls near the threshold of limiting resolution of the 0 65 N A objective The optical insulation of these fibres was also tested by forming the image of a knife edge and observing the intensity gradient in the transmitted image

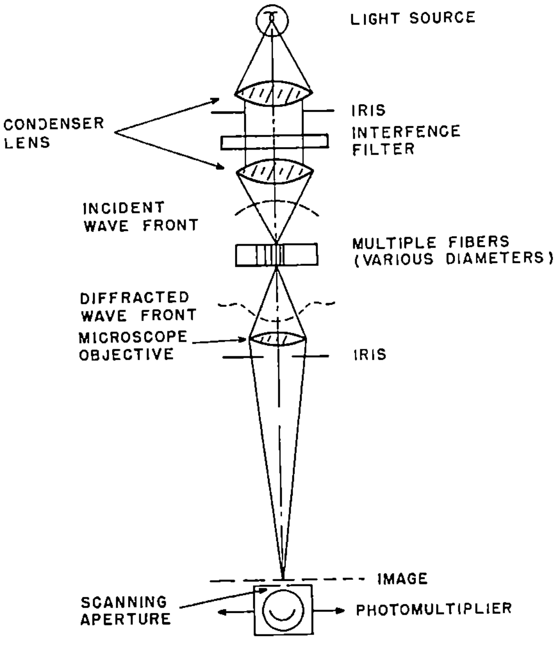
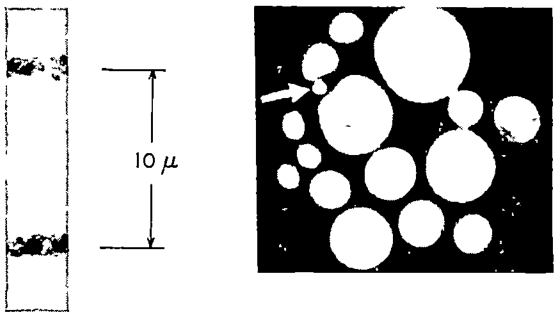
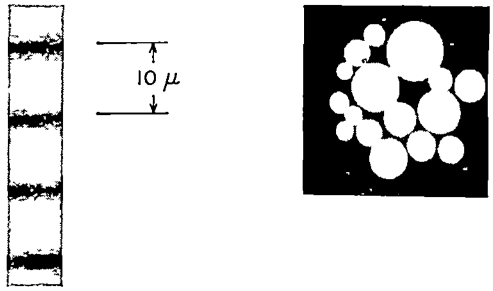


Fig 3 Illustrating the optical system for studying the flux density in the diffracted wave by multiple fibres of various diameters



$(N\,A)_{OBJ} = 1\ 3$ WHITE LIGHT

$(N\,A)_C = 0\ 8$ (a)



$(N\,A)_{OBJ} = 0\ 65$ $\lambda = 663\ m\mu$

$(N\,A)_C = 0\ 8$ (b)

Fig 4 Photomicrograph of variable diameter multiple fibres (0 75–8μ diameter) obtained on the optical arrangement in Fig 3 A 0 75μ diameter fibre is pointed out by the arrow

From the results of these experiments, and basic theoretical studies, the following conclusions are derived To a first approximation, the diffraction in straight circular fibres above two wave-lengths in diameter occur primarily at the two ends The incoherent wave incident on a fibre suffers diffraction at the entrance dielectric aperture The diffracted wave then suffers total reflexions and phase changes along its passage in the fibre until it arrives at the emergent end, where it suffers diffraction again This, of course, assumes that the refractive index of the fibre core and surround is such that the critical angle conditions for the wave in the fibre are satisfied It is clear that for a plane monochromatic incident wave, as the diameter of the fibre decreases, so the emergent diffracted cone angle increases On the other hand, as the fibre diameter goes down, so the required N A of the optical system receiving the image from the fibres goes up, in order that full use is made of the smaller diameter fibre resolution. For smaller fibres ($d > \lambda$) the limiting resolution of the optical system is set by the fibre coating ($\simeq \lambda$) Thus, most of the energy emerging from fibres down to 1μ in diameter is received by the appropriate N.A optical system These conclusions are also substantiated by a parallel study using microwave analogues of fibre optics at 1 25 cm wave-length and polystyrene cylinders Theoretical and experimental studies of diffraction by fibres smaller than the wave-length and the boundary wave skin effect are now in progress

From the foregoing it is evident that the optical performance of fibres down to a few microns in diameter do not suffer due to diffraction effects An appropriate assembly of 1μ diameter fibres is capable of a static resolution of 500 lines/mm and dynamic resolution of nearly 1,000 lines/mm Fibre optics in the ultra-violet region are capable of even higher resolution Multiple fibres have rendered such fibre optical systems practical The impact of these investigations on such applications of fibre optics as flexible endoscopes, field flattener and image transfer from Lambertian emitters is evident These results are also relevant to some basic studies of the visual mechanism in the retinal rods and cones

Acknowledgment is due to A Brushenko and D F Capellaro for valuable assistance

[1] Kapany, N S , Appendix N, "Concepts of Classical Optics", by John Strong (1958)

[2] Kapany, N S , *et al* , *J Opt Soc Amer* , **47**, 5, 413, 423 , **47**, 7, 594 , **47**, 12, 1109 (1957)

[3] van Heel, A C S , *Nature*, **173**, 39 (1954)

[4] Hopkins, H H , and Kapany, N S , *Nature*, **173**, 39 (1954)

[5] Kapany, N S , *J Opt Soc Amer* , **49**, 8, 770, 779 (1959)

PALÆOMAGNETIC STUDIES OF CENOZOIC VOLCANIC ROCKS IN NEW ZEALAND

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POSTULATED reversals of the geomagnetic field[1] offer a potential tool for the chronological subdivision and correlation of lavas within a restricted volcanic province[2–4] On a broader scale they provide potential world-wide datum planes of virtually instantaneous time significance so far as most geological processes are concerned. For reversals to be useful for long-range correlations, not only must their reality be established, but also the length of time between reversals must not be too small in comparison with the time duration of stratigraphically separable stages An early Pleistocene reversal as postulated by Roche[5], Hospers[6], Einarsson[4] and others should prove to be of considerable importance in Pleistocene chronology if it is established that only one such simultaneous reversal occurred during Pleistocene time On the other hand, it may be much more difficult to establish contemporaneity of early- or pre-Tertiary reversals Detailed study of many well-dated suites will be required to demonstrate whether long-range correlation of reversals can be effected, and if so, to determine the date at which each reversal occurred Data from some New Zealand rocks are here recorded as a contribution towards the solution of these problems Correlations of New Zealand stages follow the table of Hornibrook[8]

1 *Pleistocene* Ignimbrite sheets of the Whakamaru district, North Island, New Zealand, are normally magnetized[9] According to J Healy (personal communication), they probably belong to the Hawera or late Castlecliffian stage (Upper Pleistocene) Tholeiitic basalt at Timaru overlying gravels of the Waitotaran (Upper Pliocene) to Nukumaruan (Lower Pleistocene) and possibly itself of Nukumaruan age (Gair, H S , personal communication) is found to have reverse magnetization (north pole directed downwards, dip 75°, declination 228°)

2 *Late Middle to Upper Miocene* The directions of magnetization have been measured of more than fifty suites of rocks from the Dunedin Volcanic Complex, which has been divided[10] into an Initial, and First, Second and Third Major Eruptive Phases Each suite consisted of 3–8 (usually 5–6) specimens collected where possible over some tens of yards of exposures in road cuts, quarries and cliff sides Results from exposed, craggy outcrops are not here considered. Collections were made from sequences of flows in localities scattered over an area of about 12 × 15 miles The results from each suite have been treated by Fisher's method to obtain the mean directions which are shown in the figures

Basalts, kaiwekite, phonolites, atlantite and trachyandesites from the First and earlier parts of the Second Major Eruptive Phase all indicate essentially normal magnetization (Fig 1) In contrast, all flows sampled from the upper part of the middle sub-phase (2 *M*) and the late sub-phase (2 *L*) of the Second Major Eruptive Phase (above flow 21 of the North Head sequence[12]) show reverse or anomalous directions of magnetization (Fig 2) Basalts, trachyandesites and phonolites are plotted, the basalts being the most consistent Dotted lines join points representing mean directions of magnetization calculated from two localities in the one

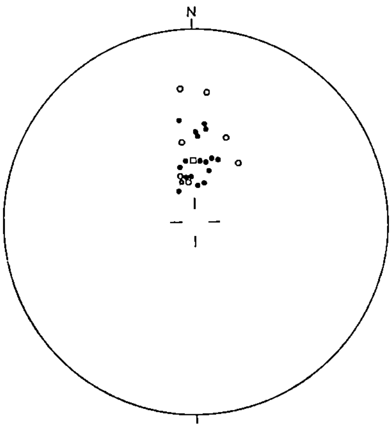

Fig 1 Directions of magnetization for lavas of First and earlier parts of Second Major Eruptive Phase Dunedin district, plotted on equal area projection ●, North pole directed upwards, radius of circle of confidence, 5 per cent level, < 12° , ○, north pole directed upwards, radius of circle of confidence, 5 per cent level, 12–15° , □, direction for symmetrical axial dipole field, latitude 46° S

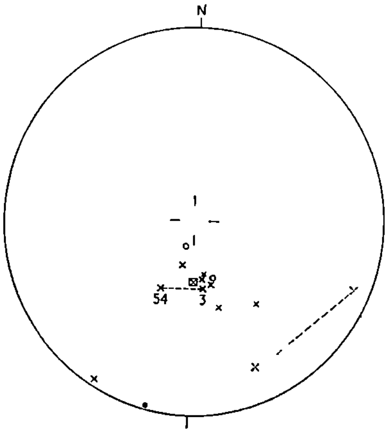

Fig 2 Directions of magnetization for lavas of the upper-middle and late sub-phases of the Second Major Eruptive Phase, Dunedin district **X**, North pole directed downwards, radius of circle of confidence, 5 per cent level, < 12°, ×, north pole directed downwards, radius of circle of confidence, 5 per cent level, 12–20°, X, north pole directed downwards, radius of circle of confidence, 5 per cent level, > 20°, ●, north pole directed upwards, radius of circle of confidence, 5 per cent level, < 12°, ○, north pole directed upwards, radius of circle of confidence, 12–20° ☐, direction for reversed symmetrical axial dipole field, latitude 46° S

flow (for example, Roslyn doleritic basalt, 3 and 54) The Leith Valley trachyandesite and some similar flows of this period are weakly and erratically magnetized in directions which are consistent only in that they are abnormal These have not been plotted We can detect no consistent trend with time for these abnormal directions, and instability is possible, although 'magnetic cleaning' experiments of several types have failed to make them significantly more consistent. Three basalts and two weakly magnetized phonolites of the Third Major Eruptive Phase give normal directions while two other weakly magnetized phonolites correlated with the same period show anomalous declinations (Fig 3)

There is thus a fairly clear sequence normal—reverse (plus anomalous)—normal in this petrographically diverse volcanic complex The age of the earlier First Phase volcanics has been established[11] as later Waiauan (latest Middle Miocene) or possibly early Tongaporutuan (earliest Upper Miocene) The upper age limit is not clear although activity probably did not extend far into the Pliocene If the hypothesis of world-wide contemporaneity of reversals is accepted, a plausible correlation of the reverse period would be with the Upper Miocene–Lower Pliocene (Pontian–basal Plaisancian) reversal reported in France[3,5], but the possibility that it represents an earlier reversal within Upper Miocene time cannot at present be eliminated

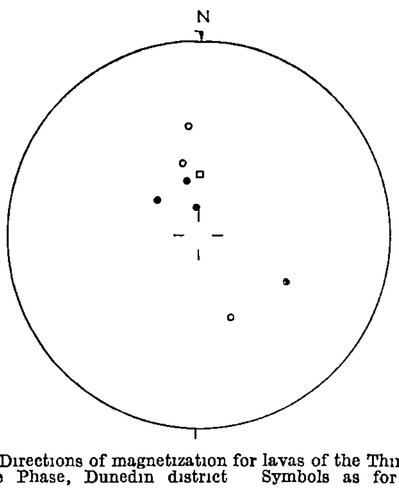

Fig 3 Directions of magnetization for lavas of the Third Major Eruptive Phase, Dunedin district Symbols as for Fig 1

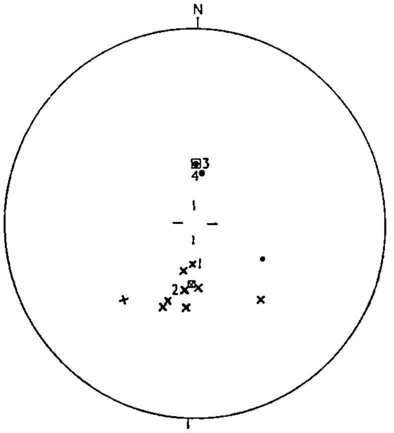

Fig 4 Directions of magnetization for Upper Eocene–Lower Oligocene volcanics of north-east Otago Symbols as for Figs 1 and 2

3. *Eocene–Lowermost Oligocene* Pillow lava (1), and a dolerite sheet (2) at Oamaru, North Otago, together with a series of dykes and other intrusions of dolerite at Moeraki Peninsula, show reverse magnetization The results plotted (Fig 4) have been corrected for post-consolidational tilting The pillow lava occurs above tuffs correlated with the Kaiatan stage and immediately below tuffs and tuffaceous limestone bands with microfaunas of Kaiatan or Runangan age, that is, earlier or later Upper Eocene (Hornibrook, N de B, and Marwick, J, personal communication) The Moeraki rocks are also placed in the Kaiatan or Runangan stages on microfaunal evidence (Scott, G. H, personal communication), whereas the Oamaru sheet is Whaingaroan (earlier Lower Oligocene)[13] A dyke (3) and sheet (4) at Enfield, North Otago, of approximately the same age have normal magnetization

An Upper Eocene period of reversal is indicated The evidence does not show whether this continued through to Lower Oligocene times, or whether one or more periods of normal magnetization intervened The North Otago results are also of interest in that, together with the later Tertiary and Pleistocene results, they do not suggest any measurable polar wandering with respect to New Zealand since Late Eocene times

We are grateful for the assistance of a number of colleagues Dr A J R White has given much help in the field, and a grant to one of us (D S C) from the University of New Zealand Research Fund is gratefully acknowledged

[1] Runcorn, S K, "Adv Phys", 4, 244 (1955)
[2] Hospers, J, *Geol Mag*, 91, 352 (1954)
[3] den Boer, J C, *Geophys Abstr*, **171**, 272 (1957)
[4] Einarsson, T, "Adv Phys", **6**, 232 (1957)
[5] Roche, A, *C R Acad Sci*, 233, 1132 (1951)
[6] Hospers, J, *Proc Kon Nederl Akad Wetenschappen*, Ser B, **56** 467 (1953) **57**, 112 (1954)
[7] Opdyke, N D, and Runcorn, S K, *Science*, **123**, 1126 (1956)
[8] Hornibrook, N de B, *Micropaleontol*, **4**, 25 (1958)
[9] Hatherton T *N Z J Sci Tech*, B, 35, 421 (1954)
[10] Benson, W N, in Fleming, C A, "Lexique Strat Int", **6**, Fasc (1959)
[11] Coombs, D S, White, A J R, and Hamilton, D (in preparation)
[12] Marshall, P, *Quart J Geol Soc*, **70**, 382 (1914)
[13] Gage, M, *N Z Geol Surv Bull*, N S, **57** (1955)

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, November 9

Institution of Electrical Engineers, Electronics and Communications Section (at Savoy Place, London, W C.2), at 5 30 p m —Prof A L Cullen "Theory of the Travelling-Wave Parametric Amplifier", Dr P J B Clarricoats "The Gain of Travelling-Wave Ferromagnetic Amplifiers", Mr A Jurkus and Mr P N Robson "Saturation Effects in a Travelling-Wave Parametric Amplifier"

Royal Geographical Society (at 1 Kensington Gore, London, S W 7), at 8 30 p m —Mr A J Marshall "Pearl and Cattle Country of the Kimberleys"

Tuesday, November 10

Institute of Physics (at 47 Belgrave Square, London, S W 1), at 5 30 p m —Dr F G Champion "Electronic Properties of Diamonds"

Illuminating Engineering Society (at the Federation of British Industries, Tothill Street, London, S W 1), at 6 p m —Mr A H McKeag "Research in Phosphors"

Wednesday, November 11

Institution of Gas Engineers, British Coke Research Association, and the Coke Oven Managers' Association (in the Lecture Theatre of the Institution of Civil Engineers, Great George Street, London S W 1), at 2 30 p m —Mr G W Lee "The First Year of the Coke Research Centre"

Institution of Mechanical Engineers, Lubrication Group (at 1 Birdcage Walk, Westminster, London, S W 1), at 6 p m —Mr A D Newman "Extreme Pressure Lubricants for Marine Gears"

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W C 1), at 6 30 p m —Dr R P Gannon "Physiological and Acoustical Aspects of Hearing"

Oil and Colour Chemists' Association, London Section (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W 1), at 7 p m —Mr R R Davidson "Whiting Dispersions, Particle Packing and Surface Adsorption"

Thursday, November 12

Institute of Metals, Metal Physics Committee (at the Royal Institution, 21 Albemarle Street, London, W 1), at 9 30 a m.—Symposium on "The Application of Thin-Film Techniques to the Electron-microscopic Examination of Metals"

University of London (in the Anatomy Theatre, University College, Gower Street, London, W C 1), at 1 15 p m —Dr E H S Burhop "Transient Forms of Matter" *

Royal Society (at Burlington House, Piccadilly, London, W 1), at 4 30 p m —Mr J Davis, Mr J S Greenhow and Mr J E Hall "Combined Photographic and Radio Echo Observations of Meteors", and "The Effect of Attachment on Radio Echo Observations of Meteors"

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W C 1) at 5 30 p m —Dr M H F Wilkins "The Molecular Structure of Chromosomes" * (Ninth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation Further lectures on November 17, 19, December 1, 3, 8, 10)

Society of Chemical Industry, Heavy Organic Chemicals Group (at 14 Belgrave Square, London, S W 1), at 6 p m —Mr D G Smith "The Production of Bulk Organic Chemicals" (Inaugural Lecture)

Textile Institute (joint meeting with the Clothing Institute, at the British Colour Council, 13 Portman Square, London, W.1), at 6 45 p m —Mr J David, Dr T H Morton and Mr W Garner "Looking Ahead in the Clothing Industry"

Friday, November 13—Saturday, November 14

Institute of Physics, X-Ray Analysis Group (at the Institution of Civil Engineers, Great George Street, London, S W 1), at 10 a m on Friday and 9 30 a m on Saturday—Autumn Conference—"Structure Analysis and Experimental Techniques"

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned

Assistant Lecturer or Lecturer in Mechanical Engineering —The Registrar, University College, Singleton Park, Swansea (November 7)

Head of the Department of Applied Physics, Head of the Department of Mathematics, Head of the Department of Aeronautical Engineering, Head of the Department of Building and Civil Engineering—The Registrar, Lanchester College of Technology, Coventry (November 9)

Senior Lecturer or Lecturer (with a good honours degree and relevant teaching experience) in Mathematics at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W C 2 (November 13)

Research Officer (with a degree in horticulture, agriculture or economics, and preferably a knowledge of horticulture or farm crop production), to carry out investigations into the economics of horticulture—The Secretary, School of Agriculture, The University, Cambridge (November 18)

Lecturer (with good academic qualifications and experience in the field of electric power engineering, preferably electrical machines) in the Department of Electrical Engineering—The Registrar, The University, Leeds 2 (November 20)

Research Officer (honours graduate in engineering or science (or equivalent), with postgraduate experience in the design of radio and electronic equipment) in the Division of Radiophysics, Commonwealth Scientific and Industrial Research Association, Sydney, N S W, Australia, to lead the research of a small group responsible for development and application of new electronics and radio-frequency techniques, particularly in U H F and microwave receivers for use in radio astronomy observations—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W C 2, quoting Appointment No 780/199 (November 20)

Senior Lecturer, Lecturer, and an Assistant Lecturer in the Department of Electrical Engineering—The Registrar, Royal Technical College, Salford (November 21)

Assistant Librarian in the Philosophical Library—The Secretary, Philosophical Library Committee, The University, Free School Lane, Cambridge, marking envelope "Application" (November 23)

Lecturers (2) in Psychology at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, November 30)

Plant Breeder (with at least a B Sc degree in agriculture or botany and experience in plant breeding or genetics) in the Section of Plant Breeding and Genetics, for duties involving the breeding and selection of sugar-cane varieties—The Director, Mauritius Sugar Industry Research Institute, Réduit, Mauritius (November 30)

Senior Research Officer and a Research Officer (qualified zoologists with experience of fisheries research) in the Department of Zoology, University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Hong Kong, November 30)

Research Fellow (with at last two years research experience, and preferably experience in high vacuum techniques or in solid state chemistry) in the Chemistry Department, for the study of fundamental processes occurring between lead and reactive gases—The Registrar, University of Melbourne, Carlton, Victoria, Australia (December 4)

Professor of Applied Mathematics at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1, or The Registrar, University of Queensland, Brisbane, Queensland, Australia (Australia and London, December 15)

Senior Lecturer in Anthropology at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (Australia, December 15)

Waynflete Professor of Physiology—The Registrar, University Registry, Oxford (December 17)

Tucker–Price Fellow for Research in Mathematics, Natural Sciences, or an allied subject and a Rosalind Lady Carlisle Fellow, for research in any other branch of learning—The Secretary, Girton College, Cambridge (January 15)

Fisheries Officer (with a university degree in biology with emphasis on zoology, and experience of fisheries work) in the Northern Region of Nigeria for development of river fisheries and the demonstration and organization of peasant fish culture—The Director of Recruitment, Colonial Office, London, S W 1, quoting BCD 65/408/01/T

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NATURE AND THE RECENT PRINTING DISPUTE

THE printing dispute which for about six weeks held up much printing and publishing in Britain is now happily over. Unfortunately, during that period it was not possible to publish *Nature*; nevertheless, contributions continued to be submitted from all parts of the world at the usual rate and volume. This meant that the Editors were able to function and face their normal duties during the dispute; but abnormal problems arose afterwards.

Now that the dispute has been resolved, type-setters, block-makers, printers and publishers throughout the country are finding themselves tied by commitments and inundated with requests. *Nature's* problem is not only to catch up as quickly as possible but also to accommodate the many contributions which have been accepted before, during and since the strike. Goodwill is prevailing among all those concerned with producing the journal, and a spirit of understanding emanates from the scientists themselves. These the Editors gratefully acknowledge.

However, in spite of all efforts being made by the printers, who have been so completely and competently in charge of the production of *Nature* for the past well-nigh thirty years, it has proved desirable to invoke the aid of other type-setters and printers, especially if the immediate aim is to be dual-purpose, that is, come up to date quickly but not at the cost of volume of work published. Again we are happy to record that everyone connected with this move and the extension of activities is co-operating closely. Nevertheless, such a project, involving as it does the transfer of some manuscripts not set, some type of those partially or completely set and the selecting of when and where these are to be sent for finishing and collating, is proving to be a heavy burden, especially on the Editors. Yet this work is being carried out successfully and in good heart; and it is to be hoped that full issues of *Nature* will soon be appearing on their appropriate dates.

Nevertheless, so complicated is this work that whereas some communications are delayed, others are being published more quickly than is normal. No doubt the authors who are suffering the longest delay are those whose manuscripts were only partially ready for printing when the dispute began. The Editors regret that in such cases they had no choice in the matter, and nobody can be blamed for this temporary set-back.

As readers of *Nature* will have noted, the present modifications of normal procedure have resulted in each issue being published in two parts—the "Letters to the Editors" appearing as a supplement.

Although this will help to expedite the publication of letters, and ease the strain on the rest of the journal, and although this will soon mean that even more communications than hitherto can be published, now is an appropriate time for enlisting the assistance of contributors and indicating how they can help—though it should be stressed that the following comments apply to any journal at any time.

When referring to the preparation of manuscripts for press, in a lecture delivered before the Royal Society of Edinburgh some years ago, Mr. L. J. F. Brimble suggested that a would-be author should ask himself the three following questions before mailing his manuscript: (1) Have I said what I really mean? (2) Have I said it in the minimum number of words? (3) Is it necessary to say it at all? The fact that this was quoted in at least eighty journals throughout the world and afterwards personally reiterated by other editors indicates that authors might well ponder such queries for the sake of themselves, their readers and their editors.

By and large, an editor reserves the right to assist an author in deciding the answer to the third question, at any rate so far as his own journal is concerned; yet, even if acceptable, articles and other communications could often be much improved before submission for publication, and for this the author and/or his advisers are entirely responsible. For example, corrections in proof are exacting for a type-setter, time-consuming for him and the printer, costly to the publisher (and in the case of some journals to the author himself) and frequently irritating to the editor, especially when the last-named knows full well that more careful preparation of the manuscript in its initial stages would have rendered many such corrections unnecessary. In the case of *Nature*, costs of corrections are borne by the publishers.

There are authors who still rush their manuscripts to an editor knowing that they have not yet said the last word on the subject, but who aim at correcting and improving (?) in proof. Recently, for example, the manuscript of a communication to *Nature* contained the following numerical values: 7·28 ± 0·82, 8·92 ± 1·09 , these were changed to 11·15 ± 1·30, 5·12 ± 0·85 in the proof.

Although in general authors are reasonable with their corrections, there are those contributors whose corrections cost more than the original setting. Perhaps the most expensive author is he who does not hesitate to make changes on the proof of an illustration which he himself had originally prepared, apparently assuming that such changes are possible. Actually, except in the case of very minor alterations, a new block has to be made, which may cost several pounds sterling.

Another problem which must now be facing all editors of scientific journals and certainly most readers of such journals is that of abbreviations. Obviously, many of these, symbols, etc., are essential to such an exact discipline as science; but among a high percentage of scientists to-day the devising of abbreviations seems to have developed into a cult. Often the straightforward full word is all that is needed; but even more important in any journal which covers all branches of science, it must be borne in mind that an abbreviation often has more than one meaning, especially between one subject and another. For example, a geologist recently submitted a communication containing the letters B.C. to mean Boulder Clay. To most biochemists PAS means periodic acid-Schiff; but to others it may mean *para*-amino-salicylic acid. The symbol H has been adopted by some to indicate histamine; but for a very long time to all scientists it has been the symbol for hydrogen. One author expected the editors to use the expression cytidylic acid-U-C^{14} to mean "uniformly labelled cytidylic acid with respect to carbon atoms contained therein". To a few authors the letters D.C.L. stand for Distillers Co., Ltd., whereas in the much wider field of academics these have a quite different connotation. Some physiologists indicate cardiac output by the abbreviation CO which might well confuse others. One author who wrote M.I.T. to mean monoiodotyrosine had apparently not heard of the Massachusetts Institute of Technology.

There is no doubt that many abbreviations are essential for they can be so exact; but there are certainly a number of authors who apparently imagine that their articles appear more 'scientific' if these are peppered with abbreviations. Although the Editors of *Nature* are now well versed in abbreviations adopted by scientific writers, such is the present height of this Tower of Babel that the former sometimes have to refer a communication back to an author asking what he means. This is, to say the least of it, a waste of time. Recently a communication received had anything from one to three abbreviations in each line (some obviously made up by the author himself). The communication defied interpretation; yet after the author had been shown the error of his ways, the revised manuscript, without a single abbreviation, revealed an elegant and interesting piece of research work. But before that communication could be published it had to pass backwards and forwards three times half-way around the world.

It is not irrelevant to point out now that, despite many efforts at achieving standardization in scientific presentation, journals vary considerably, though each one endeavours to be consistent within itself. It would save much time and, indeed, be a courtesy to any editor, if an author consulted beforehand the journal to which he proposes submitting his manuscript. He would certainly obviate the risk of errors. For example, *Nature* endeavours to be consistent in the way footnote references are inserted; yet frequently authors adopt their own methods (or those of other journals), and these, sometimes being quite different from *Nature's* custom, involve extra work on the part of the Editors and the risk of wrong quotations or citations.

Perhaps the most problematical of all authors is he who wishes to withdraw his communication after it has been submitted. The timing of such withdrawal is often very awkward. If the author withdraws at about the same time as the editor decides to reject then little harm has been done. But if the author withdraws, as he sometimes does, after the communication has been set in type, then considerable costs have been incurred and the time of editors, type-setters (and sometimes even block-makers and printers) has been wasted. Moreover, if the request to withdraw comes after the contribution has reached page-proof stage, then really difficult editorial and printing problems arise. An author is therefore well advised to ponder his communication after he has written it, and scrutinize fully the possible consequences to himself and the readers of his communication, before submitting it to any journal; for there is the ultimate risk, which sometimes occurs, that it is too late to withdraw the publication, anyhow.

The foregoing suggestions and observations should be considered carefully by all likely contributors to the columns of *Nature*, for they apply at any time, though never so urgently as at present. It is to be hoped that all authors and readers will recognize the inevitability of a certain amount of delay during this period of getting back to normal; though we have already reached the stage when genuinely urgent material can be dealt with promptly. The time is not far off now when *Nature* will again be on an even keel so far as date of publication is concerned, and equally as soon it is hoped that even more text than hitherto can be accommodated.

The Editors gratefully acknowledge the assistance given and co-operation shown by all type-setters, block-makers, printers and publishers during what has turned out to be the most exacting period in *Nature's* history; and everyone concerned with the production of the journal has been encouraged by the sympathetic understanding shown by scientists the world over.

FORTY-SEVEN AUTHORS IN SEARCH OF A CONCLUSION

Virus Growth and Variation

Ninth Symposium of the Society for General Microbiology held at the Senate House, University of London, April 1959. Edited by A. Isaacs and B. W. Lacey. Pp. viii+272. (Cambridge: At the University Press, 1959. Published for the Society for General Microbiology.) 35s. net.

Perspectives in Virology

A Symposium. Edited by Morris Pollard. Pp. xix+312+2 plates. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959. Published for the Institute of Microbiology, Rutgers University.) 56s. net.

Advances in Virus Research

Vol. 6. Edited by Kenneth M. Smith and Max A. Lauffer. Pp. viii+382. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1959.) 10 dollars.

THE most integrated of these three volumes is the collection of essays on virus multiplication that the Society for General Microbiology expected those attending the symposium, that it arranged in April, to have bought and read before the meeting.

There is now fairly general agreement with the opinion, stressed by some when the same symposium was held in 1952, that virus multiplication cannot usefully be compared to the growth of a micro-organism on an inert medium. Rather, it is the exploitation and diversion of the pre-existing synthetic capacities of the host cell. One product of this anomalous metabolism is material that resembles the intruder. It is, however, clear from the papers by Harrison and Hoskins that the host has definite synthetic preferences. Not only is there the well-known insusceptibility of most organisms to most viruses, but there are many examples of variation induced by the host. Virus infection is a general metabolic derangement, and the derangement often precedes any apparent virus multiplication.

Luria, Kellenberger and Hirst stress the analogy between genetic processes and virus multiplication. It may well be that this is more than an analogy and that there is substance in Muller's suggestion in 1922 that viruses could be likened to free genes. Some writers, though not those quoted, have followed the analogy blindly and made it seem ridiculous. Put in sober biochemical terms, it amounts to the proposition that, among the mechanisms deranged, are those normally concerned with the production of whatever it is that genes are made of and of the nucleoproteins of chromosomes. Enthusiasts will find that a colourless way to put the matter, but this may serve to bring out the diversity of the problem. There was a time when some biochemists announced resoundingly that they were studying 'oxidations' or even 'enzyme actions'; we now have the sense to state the substrate and tissue actually used. So, too, with viruses. Different viruses in the same host interfere with different processes and the normal processes most commonly deranged vary from host to host. This book makes it abundantly clear that there is no one answer to the question, "How do viruses multiply"?

"Perspectives in Virology" is less integrated. It contains a charming essay by Dubos on the breaking of tulips; he realizes that a perspective can point in any direction. On the historical framework of the part played by this virus infection in promoting the spread of tulips around the world, he discusses the irrationality of the criteria by which we commonly distinguish symbionts from pathogens. The puzzling relations between pigs, earthworms, lungworms and the hog cholera virus are clearly and thoughtfully set out by Shope. Almost half the symposium is devoted to tumour causation. Kilham discusses transformations and points out that many effects are as likely to be the result of the failure of a restraint as of the appearance of a new capacity. Beard deals with current work on viruses as a cause of cancer. This is a sensible article marred by the isolationist syndrome that often makes American scientists concentrate on work done in their own country. Its historical perspective is also limited; thus Gye does not appear among the 114 references. Fashions in science are cyclical, so that one advantage of a knowledge of the older literature is that it gives one an up-to-date, or even advance, perspective on contemporary controversy. The names change but the issues remain much the same.

The papers making up this symposium were apparently presented in February 1958, and the discussion that followed is printed though some of it is rather slight. Verbatim treatment has, however, the immense advantage that it preserves several of Peyton Rous's reminiscences and anecdotes, and these might well have been shorn from a strictly edited version.

"Advances in Virus Research" appears annually and is, naturally, without unity. A third of this issue is devoted to a review by Sonneborn on kappa and related factors in *Paramecium*; it is comprehensive and includes a valuable survey of similar bodies found in other protozoa and in insects, and a discussion of the reasons for looking on a particle as large as kappa as a virus. In the course of this he discusses the limits of the category 'virus' and this is probably the main reason for including the essay in the volume. But it would have made an excellent 127-page book on its own. Two articles deal with the purification procedures used for plant and poliomyelitis viruses. It is useful to have all these methods collected together, but it may be that the authors under-rate the extent to which differences in the precise state of the host tissue, normally used in different laboratories, will affect the way in which these methods work in practice. Consideration is also given to the inactivation of polio virus for use as a vaccine; here it is puzzling to find attention concentrated on formaldehyde. There are many other potentially useful inactivating agents with more systematic and predictable behaviour. There are lucid articles by Brenner on phage genetics and by Broadbent and Martini on the spread of plant viruses. The latter give so many examples of transmission through seeds that we can no longer regard this as unusual.

A review of thirty-six articles is necessarily selective; a list of titles and authors alone would nearly have filled the space allowed. In general, the standard is high and it is by no means a bad thing that widely different audiences are aimed at. One wonders, however, whether such ephemeral material needs to appear with so expensive a format. The total cost of these three volumes is £8. N. W. PIRIE

FROM AXES TO ATOMS

Man the Maker

A History of Technology and Engineering. By Prof. R. J. Forbes. Pp. xvi+365+41 plates. (London: Constable and Co., Ltd., 1958.) 30s. net.

"MAN the Maker" is certainly the most flattering image of him. For whatever else may be dubious in man's relatively brief history, there is no doubt that his capacity to make (or, rather, construct for man creates nothing) has steadily increased. Beginning with no more than the power to chip and hack, endowed with an instinctive dexterity less than that of some insects, he has acquired tool after tool and mastered process after process, until he can rearrange to accord with (at least partially) predetermined patterns all the component parts of the universe within his range, from the particles of the nucleus to millions of tons of rock and water. The growth of man's power, as Prof. Forbes tells it, is the strongest confirmation of progress that history can offer. It is a story without retrogressions, without Dark Ages. Further, he is right to insist that this growing power has been used for constructive purposes, unless we would limit men to the status of feeble parasites. As the first men took flesh from animals and branches from trees, their successors have gone on to pillage the Earth and poison the air on a scale ever proportionate to their growing power, for they could not build without materials nor beautify without making ugliness. But build they did and as a result human life has become ever more secure and comfortable and its focus has moved from the stomach to the brain.

The history of technology divides into two essentially different overlapping phases. The first is the development of craftsmanship, the limit of which is whatever is best of its kind, though not necessarily for its function. Some stone axes are perfect examples of craftsmanship, but a Woolworth's one is a better tool. The second is the transfer of craftsmanship to the machine and the factory, the production of which has no limit in whatever is good or bad. Once man had learnt to hunt and grow, to carpenter, smelt, and weave, as he had by about 2,000 B.C., the early history of techniques is largely concerned with the development of the fine crafts of the potter, silversmith, silk-weaver and dyer. Such artisans possessed the most advanced skills. Under successive empires from the Egyptian to the Holy Roman they supplied their masters with beauty and luxury while the life of the peasant masses continued essentially unchanged, equally ungraced by the pottery of Corinth or Deruta, by the steel of Noricum or Toledo, by the linen of Pharaohs or the scarlet of kings. So far as the majority of humanity was aware of the finest works of ingenuity in machines, in architecture, in weapons or in pageantry, it was aware of them as arousing superstitious wonder or deferential awe. Until some 500 years ago technological progress, the use of metals and of bright colours, the building of clean, solid houses, the availability of transport and of variety of food, diffused downwards to the masses of Europe and Asia with incredible slowness. Nor in the age of craftsmanship could it be otherwise. Beginning under the Romans, however, and gathering momentum during the Middle Ages in Europe, is a new trend that will break down such restrictions, the importance of which is fully recognized by Prof. Forbes. This is the use of powered machines. The most astonishing fact in his book is given on p. 328: half the available energy in the United States is consumed by its inhabitants for their private uses, the other half being nearly evenly divided between manufacture and conversion-losses. That is the true sign of the affluent society.

The author, whose association with Royal Dutch Shell and experience as a historian of science and technology give him unique authority, has devoted more than a third of his book to the earlier phase of man's career as a maker. This section of the book, though it can enter into little detail of how things were done by the laborious craftsman, gives a clear and balanced account of the origins of the chief manufactures; nor are their social effects ignored. The later and longer section on the last five hundred years has much detail of inventions and their development. Prof. Forbes shows a wise caution in appraising the contribution of pure science to invention and the revolution in technology: the importance of science in this respect is little more than a century old. The extension of the wind- or water-driven machine from corn-milling to fulling, smelting, pumping, spinning and weaving; the use of coal as a fuel and cast iron as an engineering material; the mastery of steam and the beginnings of industrial chemistry were all effected through craft empiricism. Changes in industrial organization were scarcely less productive than the new techniques. The effects of science in the nineteenth century were wrought on a world already changed, crudely perhaps, yet reaching towards "a rational exploitation of the material world on behalf of the common good". Through machinery and power, through book-printing and cotton-manufacture, railways and precision lathes, sulphuric acid, soda and glass, quantity production was offering the earth-bound peasant more than the whole history of craftsmanship had ever provided for the few. That, one cannot deny, is progress in making.

The text of "Man the Maker", now re-issued, is identical (even to misprints) with that issued by Henry Schuman (New York) in 1950. The author has enlarged the epilogue by several pages and has revised the bibliography. Although historians of technology are not idle, the book is still the broadest, most readable and complete survey of the field. It is written with continuity, perspective and social sense. Some casual statements that will annoy specialists and a number of relatively trivial slips in date and name might have been corrected, but these are minor blemishes on a work that will open a new prospect of the past to many readers.

A. R. HALL

HEAVIER ELEMENTS

The Transuranium Elements

By Glenn T. Seaborg. (Yale University—Mrs. Hepsa Ely Silliman Memorial Lectures.) Pp. xx+328. (London: Methuen and Co., Ltd., 1958.) 50s. net.

THE material in this book was originally presented at Yale University in lecture form during 1957. After considerable expansion, it was published as one of the series of books produced by the Addison-Wesley Company and presented by the United States Government to foreign delegates at the United Nations Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958. It is now available in a different binding published in Great Britain by Methuen.

Prof. Seaborg has a well-established place in the discovery and elucidation of the complex chemistry of the transuranium elements, and any new publication by him is deserving of our close attention. This book is not, however, written for the specialist in this field and is of quite a different character from the highly successful volume "The Chemistry of the Actinide Elements" written in collaboration with J. J. Katz. Moreover, much of the basic material has appeared previously.

There are four main sections. The first is historical, beginning with a detailed description of the discovery of plutonium early in 1941, and continuing through the development of methods for its large-scale separation, with some digressions on the related actinide elements. This section is not easy reading despite the introduction of a considerable number of personal recollections of important events: the inclusion of long lists of names in the running text is distracting. The emphasis is on the chemists whose contribution to the success of the war-time project for the synthesis and separation of plutonium was only briefly mentioned in the Smyth Report of 1945. Although the reviewer is not in a position to judge the accuracy of detail in the accounts given of this very early work in the United States, some errors and misleading statements were detected in the brief references to the British project. As examples, no distinction is made between R W. Spence (of Los Alamos) and R Spence (of Harwell) on p 73 and in the index, and the work of Welch and collaborators on plutonium compounds (pp 87–88) is erroneously quoted as having taken place at Harwell rather than at Windscale The brief description of the Chalk River Laboratories (p 73) does not mention the important laboratory-scale development of the Windscale plutonium separation plant during the period 1945–48

The second section of the book, in which the chemical properties of the actinide elements are discussed briefly in a correlative manner, is more digestible Although one must agree with the author that the main points of the actinide concept are now well established, there will still be many chemists reluctant to see the undiscovered element 104, instead of thorium, taking the eka-hafnium position in the periodic table At the end of the book there is a shorter fourth section in which Prof Seaborg attempts to extrapolate the generalizations he has derived to predict the chemical and nuclear properties of elements well beyond those which have yet been successfully synthesized The magnitude of the experimental problem of isolating such elements is illustrated by a detailed description of the discovery of element 101 Since an average of only one atom of element 101 was expected to be produced in each experiment, the subsequent separation and identification must rank as one of the most outstanding feats in the history of chemistry

The most valuable part of this book is the third section, which deals systematically with the nuclear properties of the trans-uranium elements However, there is here, as in the rest of the book, a complete lack of detailed reference to sources of information

In summary, the book, though containing much material of interest, is written in such a way as to fall rather awkwardly between two stools Specialists in the field will prefer other expositions on the subject by the same author, while the layman interested in scientific matters will find difficulty in following the book, as a considerable background of scientific knowledge is required for a full understanding of even the historical sections

The book is well produced, with a commendable lack of typographical errors J K DAWSON

SCIENCE EDUCATION

The Challenge of Science Education

Edited by Joseph S Roucek Pp xiii+491 (New York Philosophical Library, 1959) 10 dollars

WHEN *Sputnik* was announced to a startled world in October 1957, the reaction in the United States was immediate and vigorous, but nowhere was it more unsettling than in certain radical proposals for revolutionizing the American educational system by copying that of the U S S R This book is an attempt to make a first systematic survey of the post-*Sputnik* educational practices in the field of science in the United States, the U S S R and Britain The work is edited by a former Czech, who commences with a brilliant, short historical account of the impact of science upon human thought and behaviour More than thirty collaborators are each responsible for a chapter, and these include Dr James R Killian, lately consultant to President Eisenhower, and Dr Werner Heisenberg The contributions differ in size and value as is to be expected, and the treatment of the subject is generally diagnostic and experimental rather than conclusive Standards and content in American science education vary more by reason of geographical location, religious and political factors than they do in Britain, though so far as the last is concerned, even here it still remains to be seen whether politics, which has invaded the field of secondary education, as in Derbyshire, will prove harmful to science teaching at a high level in the grammar schools The salary-levels, which affect the recruitment of suitable men and women to teach science, operate in the United States more forcibly than in Britain, and there is the added difficulty of the lower rating in social status "Don't become a teacher," said the head of one science college in the United States, "we want to be proud of all our men "

Werner Heisenberg's defence of a background education in the classics in relation to his own mental development as a theoretical physicist is most interesting and suggestive , and so are the chapters on new approaches to mathematics teaching by using the theories of sets and probability The underlying tone of the book is by no means optimistic There is a quotation from Don K Price ("Government and Science"), who concludes that "The role of world leadership is an uncomfortable one , it requires a steadiness of purpose, an economy of our energies and a breadth of philosophy that have never been characteristic of American temper"

The short account of science education in Great Britain (though it might have been more accurate to say England) by Dr Kenneth Laybourn of Bristol and the longer account of the U S S R by L A D Dellin of Vermont are very useful summaries

The documentation at the end of each chapter is excellent Every chapter is worth reading and pondering on, particularly by those who are interested in science and mathematics teaching, but generally by those who have any interest in maintaining the free world W L SUMNER

SIR CHARLES HASTINGS

The Life and Times of Sir Charles Hastings, Founder of the British Medical Association

By William H McMenemey Pp xii+516+32 plates (Edinburgh and London E and S Livingstone, Ltd , 1959) 50*s* net

IN 1951, Dr W H McMenemey was invited by the Council of the British Medical Association to deliver the first Sir Charles Hastings memorial oration, for which task he was singularly well equipped, for he had worked for several years as pathologist at Hastings's own hospital, and in 1947 had made a name for himself with his scholarly and charmingly written "History of the Worcester Royal Infirmary" An elaboration of this oration, "The Life and Times of Sir Charles Hastings" is a huge tome to which the hackneyed phrase "labour of love" may unhesitatingly be applied It will for long remain the standard biography of the founder of the British Medical Association and of the architect of the Medical Act of 1858 Dr McMenemey possesses a scholar's conscience in consulting original sources, and he quotes extensively and happily from contemporary medical periodicals, newspapers, minutes and letters, yet he wears his learning lightly and unobtrusively, and his style is both elegant and delightful. Some readers might criticize his story on the grounds that it is too detailed and too discursive, and that the lengthy accounts of his contemporaries detract from a true appreciation of the subject proper of the biography; but even those who would have preferred a more succinct narrative will yield to none in their admiration for an invaluable work of reference.

We meet Charles Hastings as a medical student at Edinburgh, where he developed "a catarrhal inflammation of the lungs", which was treated by the distinguished physician, James Gregory, and we learn that this malady inspired his lifelong interest in diseases of the chest. In 1820 was published his classic "Treatise on Inflammation of the Mucous Membrane of the Lungs", which was translated into German two years later. We accompany him to Worcester, where he was appointed physician to the Infirmary, and watch him first using the stethoscope in the summer of 1820. We read how he founded, and edited, the *Midland Medical and Surgical Reporter* in 1828, and in 1832 launched the Provincial Medical Association, which was watched by Thomas Wakley in London "carefully and with considerable suspicion". Little did Wakley realize that one day it would grow into a British Medical Association. Hastings was "the pivot around which the Association revolved, for they all looked to him for guidance and inspiration". We are told that he narrowly escaped becoming mayor of Worcester, paying a fine of £50 for having refused office. We see him in the role of naturalist and in his company attend a dinner where twenty toasts were drunk. "When the celebrants finally arose they had completed just over six wonderful hours of feasting and conviviality." It is interesting to find that in 1844 a National Association of General Practitioners was formed with seventeen branch secretaries.

Lavishly and fascinatingly illustrated, Dr. McMenemey's book bristles with bitter controversies in "disturbed and disputatious" meetings. It concludes with a bibliography of Hastings's writings, a general bibliography, and a model index. I like the chapter headings.

W. R. BETT

PANBIOGEOGRAPHY

Panbiogeography or an Introductory Synthesis of Zoogeography, Phytogeography, and Geology, with Notes on Evolution, Systematics, Ecology, Anthropology, etc.

By Léon Croizat. Vol. 1: The New World. Pp. 1018. Vol. 2a: The Old World. Pp. iii+1–771. Vol. 2b: The Old World (continuation). Pp. iii+772–1731. (Codicote, Nr. Hitchin: Wheldon and Wesley, Ltd., 1958.) £16 10s. (paper bound).

IT is a distinct understatement to call this enormous work unusual. Published in three separate books making up two volumes which weigh something like ten pounds unbound, it contains 2,700 pages and probably at least a million words. To this must be added that it is highly prolix and repetitive; that it is written in a peculiar brand of semi-colloquial idiomatic English which often obscures the author's exact meaning; and that it contains too many animadversions on biologists with whose views Dr. Croizat is not in accord. In short, the author seems to have put almost every possible obstacle in the way of the reader who wishes first to understand and then carefully to consider his opinions. This is all a great pity because there are two excellent reasons at least why this *magnum opus* should on no account be regarded as unreadable and therefore safely to be ignored.

The first reason is that the book is a vast compendium of information about plant and animal distribution which is arranged and discussed on a geographical and not a taxonomic basis, thus making it much more valuable than it might otherwise be. Indeed, the broad sweep of its geographical background is one of the book's best features. The first volume begins with an introduction, which concludes with a remarkable piece of self-criticism by the author, and is thereafter concerned with the New World in general and then with Venezuela, Colombia, Ecuador, the West Indies and Galapagos (that is, with several crucial areas) in particular. The first book of the second volume deals with Africa, Eurasia, Malaysia and Australasia; the second book covers Polynesia and is thereafter made up of conclusions; a long epilogue on evolution; and various addenda, of which the most extensive is one on physical anthropology. The chapter of conclusions is the shortest of all the chapters but also the most readable.

The second reason is that Dr. Croizat is a man of quick intelligence who has for years pondered over many fundamental problems of biology, not only in its narrower sense, but also in its wider philosophical expression in which it comprehends the whole history of the human race and of its thought. His comments and beliefs on many such subjects are interlarded, as it were, through his immensely long recital of the data of biogeography, but they often reveal great discernment and may therefore be forgiven for any digressions they cause.

As regards biogeography Dr. Croizat's main thesis is that plant and animal distribution, using this word in its more particular sense of 'dispersal', must not be studied in isolation; it is simply one aspect of the three basic factors of evolution, namely time, space and form. To quote his own words, his book "replaces the Darwinian understanding of 'species' originating at some definite spot on the map and 'migrating' *via* 'occasional means' with a fitting understanding of form-making and translation in space as a single process".

Thus, this vast book is, in essence, a study in evolution, chiefly, but by no means only, from the biogeographical point of view. It is clearly inspired by the author's discontent with the approaches to this subject of Darwin, Wallace and some of their successors, and so it is yet another contribution to the swelling stream of opinion that the general biological outlook which we now call Darwinism, however great its value may have been in the past, is no longer a suitable vehicle for progress in the biological sciences.

The maps, with which the book is liberally supplied, are open to some criticism. Most of them might be clearer and too many of them are drawn on Mercator's projection, which is quite unsuitable for depicting biological distributions. Also, they are too plentifully supplied with arrows purporting to show movement along various 'tracks' of migration. It is easy enough to postulate tracks of this sort but it is quite another thing to produce satisfactory evidence to show which way along them movement has been.

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In Preparation

Volume 8

Nuclear Spectroscopy

Edited by FAY AJZENBERG-SELOVE, *Haverford College* **Late 1959**

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ACADEMIC PRESS, New York and London

111 Fifth Avenue, New York 3, New York 40 Pall Mall, London, S.W.1

British Sales Office **Academic Books Ltd.**, 129 Queensway, London, W.2 — *BAYswater* 3149

Oxford University Press

Medical Surveys and Clinical Trials

Edited by L. J. WITTS, C.B.E.

Nuffield Professor of Clinical Medicine in the University of Oxford

During the present century a new technique of clinical research has been developed which consists of the study of disease in groups instead of—as in past centuries—in individual patients This book, which is the first to be written on this increasingly important branch of research, will prove invaluable not only to those holding full-time research appointments but also to all engaged in any branch of clinical medicine, whether as consultants or general practitioners.

The book is divided into two parts Part I, Methods and Part II, Applications The first part commences with a chapter on the general principles of group research followed by chapters on diagnosis in group research, prevalence surveys, prospective and retrospective studies, follow-up studies, prophylactic and therapeutic trials, the use of volunteers, controls, placebos, and questionnaires in clinical trials, and operational research in medicine

The second part shows how these methods may be applied in many different branches of medical science, each chapter being illustrated by a number of relevant examples which show what has already been achieved by these methods of research No attempt has been made to include all branches of clinical medicine but those selected for detailed discussion provide ample information for workers in any other branch of medicine. Part II contains chapters on genetics, the assessment of nutritive child development and health, chest diseases, cardiovascular diseases, diseases of joints, mental illness, cancer, and tropical diseases

Each chapter contains a full list of references and, in addition, a bibliography on observer variation and error has been included

Every author has written from wide personal experience and all have made a number of distinguished contributions to medical research, many of which are used as the actual working examples that appear in the different chapters of this book

CONTRIBUTORS

R M ACHESON, A C ALLISON, N T J BAILEY, B BRONTE-STEWART, G M CARSTAIRS, R DOLL, C M FLETCHER, E M GLASER, J. KNOWELDEN, J LAWRENCE, P D OLDHAM, SIR GEORGE PICKERING, H. M SINCLAIR, V H. SPRINGETT, ALICE M STEWART, S C TRUELOVE, L J. WITTS, A W WOODRUFF

336 pages 17 illustrations About (December) 35s. net

Plant Growth Substances

By Prof. L. J. Audus. Second edition. (Plant Science Monographs, No. 1.) Pp. xxii+554+34 plates. (London: Leonard Hill (Books), Ltd., 1959.) 65*s*. net.

To produce within a single volume a comprehensive and up-to-date treatment of a subject which is developing so rapidly as plant growth substances is no mean achievement. Yet in this second and revised edition of his book, Audus has done this with considerable success. As in the first edition, physiological aspects of growth-regulating activity receive careful attention throughout, but in addition a new chapter on the mechanism of action of the auxins, dealing with more fundamental physiology, is now included. Other changes in the book are shown in the more detailed treatment given to flowering control and chemical control of sexual processes in lower plants and to non-auxin type growth substances. The chapter on the chemistry of the auxins has also been considerably expanded.

Although this is an excellent book, it is perhaps pertinent to ask whether it is attempting to cater for too many classes of reader. In the reviewer's opinion, most of the contents are far beyond the reach of the "non-scientific layman", whose requirements would perhaps be met better by a book written specifically for him.

With this reservation, the present volume can be confidently recommended. It is well produced with excellent photographs and diagrams. Many references to original work are given and appendixes relating to the practical use of growth substances in agriculture and horticulture are provided. R. L. Wain

The Design of Physics Research Laboratories

A Symposium held by the London and Home Counties Branch of the Institute of Physics at the Royal Institution, 27 November, 1957. Pp. 108. (London: Chapman and Hall, Ltd.; New York: Reinhold Publishing Corporation, 1959. Published on behalf of the Institute of Physics.) 21*s*. net.

The proceedings of the symposium on "The Design of Physics Research Laboratories" held on November 27, 1957, at the Royal Institution and organized by the London and Home Counties Branch of the Institute of Physics have now been published in book form. A report of the symposium appeared in *Nature* (**181**, 90; 1958). The symposium was very timely and extremely successful. It was attended by some 400 architects, physicists and others interested in the design of research laboratories, and the book contains a full account of the proceedings, including the discussion and many of the photographs which were presented as lantern slides. Nobody who is about to plan a new physics laboratory or an extension to an existing laboratory should omit to read this volume first. It contains a wealth of excellent hints and reminders, and may save much expense in assisting to avoid faulty design and much time in providing quick and accurate reference to the authoritative literature. It is difficult to summarize the contents, but all those who have had experience of planning buildings and the responsibility of supervising the construction will agree most wholeheartedly with the statements that properly planned sound construction using lasting and easily maintained materials is the most economical, and that regular site meetings should take place between the user of the building, the architect and the most essential person, whom Mr. Emmerson calls "the building supervisor" and who should be the sole official channel of communication between the various parties concerned in the building of the laboratories. S. Weintroub

Aromatic Substitution

Nitration and Halogenation. By Dr. P. B. D. de la Mare and J. H. Ridd. Pp. vii+252. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1959.) 50*s*.

This book deals with the nitration and halogenation of aromatic compounds. Two introductory chapters cover the basic principles of electronic theory and methods used to investigate reaction mechanisms. Next follows a group of four chapters dealing with methods of nitration and the mechanism of the nitration reaction, and then a further group of four chapters dealing likewise with halogenation. The authors then review substitution in diphenyl, in polycyclic hydrocarbons, in non-benzenoid hydrocarbons, and in heterocyclic systems, and substitution reactions involving displacements of groups other than hydrogen. The final chapters deal with molecular orbital calculations of reactivity and with linear free energy relationships.

The authors have succeeded in giving an excellent, well-written and critical account of their subject. Although the book is both short and readable, no important aspect seems to have been omitted and no important papers overlooked. The authors have not been afraid to express forceful opinions on a variety of controversial issues—a pleasant phenomenon in this era of depressingly uncritical compilations. The book is, moreover, very well produced and the price most reasonable. It can be strongly recommended to any chemist interested in organic reaction mechanisms. M. J. S. Dewar

Constitutional Diagrams of Uranium and Thorium Alloys

By Frank A. Rough and Arthur A. Bauer. (Addison-Wesley Physics Books.) Pp. vi+154. (Reading, Mass.: Addison-Wesley Publishing Company, Inc., 1959.) 5 dollars.

This book, which supersedes the Battelle Memorial Institute publication, "Compilation of U.S. and U.K. Uranium and Thorium Constitution Diagrams", is a new compilation of United States and United Kingdom uranium and thorium constitutional diagrams. The book is divided into two major sections, one for uranium and the other for thorium. Each section is preceded by a short account of the transformation temperatures and crystal structures of the base metal. The method of presentation is the constitution diagram, with a short account of the investigations on the system, the essential data on the crystallography of the compounds and a list of references for each alloy. Most of the references are unclassified, but in several systems, where the unclassified literature is incomplete, some classified references are given. The various systems are listed in alphabetical order and include both binary and ternary alloys. The information on each alloy is quite comprehensive and the form of presentation is neat and concise. This publication will be extremely useful as a reference book to everyone interested, either from a theoretical or practical point of view, in the alloys of uranium and thorium. D. E. R. Hughes

SHIP HYDRODYNAMICS LABORATORY, FELTHAM

ON October 19, H.R.H. the Duke of Edinburgh opened at Feltham the new Ship Hydrodynamics Laboratory of the National Physical Laboratory.

Since 1932, when No. 2 Tank was built at Teddington, test work on models of new ships has increased in volume to a point where it has seriously impeded research. At the same time, thanks to the steady investigations undertaken over the past fifty years, research requirements have themselves changed. Increasing emphasis is falling on the seagoing qualities of ships, particularly at high speeds, and the facilities at Feltham have been specially designed for these requirements. It is expected that, in general, tests of commercial ship-models in smooth water will continue to be carried out at Teddington, while tests of commercial models in rough water and a great deal of the research will be done at Feltham. This research will include theoretical and experimental studies of ship motions in regular and irregular seas, together with a study of full-scale multi-directional sea states, propeller and hydrofoil cavitation and ship vibration. Various other research projects formerly followed at Teddington will be carried over to Feltham, where larger models can be used than is possible in the existing tanks; these will include skin friction of smooth and rough surfaces, ship-model correlation, wave-making resistance and boundary-layer investigations.

The design of the new Laboratory (Fig. 1) was developed by the Ship Division of the National Physical Laboratory working in collaboration with the Chief Architect's and Chief Engineer's Divisions of the Ministry of Works. The principal facilities at Feltham comprise a towing tank, a sea-keeping and manœuvring basin and a propeller water-tunnel for cavitation research.

The ship-testing tank is the largest of its kind in Britain. It is 1,300 ft. long, 48 ft. wide and 25 ft. deep. Its length, which is almost double that of the No. 2 Tank at Teddington (680 ft.), is necessitated by the requirements of testing models in irregular seas or at high speeds and the use of larger models of multi-screw ships. In sea-keeping tests the model must be run through regular and irregular seas for long enough time to obtain complete cycles of motion and also to ensure a long enough steady run for making measurements at high speed. The original design was for a length of 1,800 ft., but this had to be reduced in order to keep within the funds available, and the present length represents the minimum for fulfilling these requirements. The site, however, has been planned so that the additional length can be added in the future.

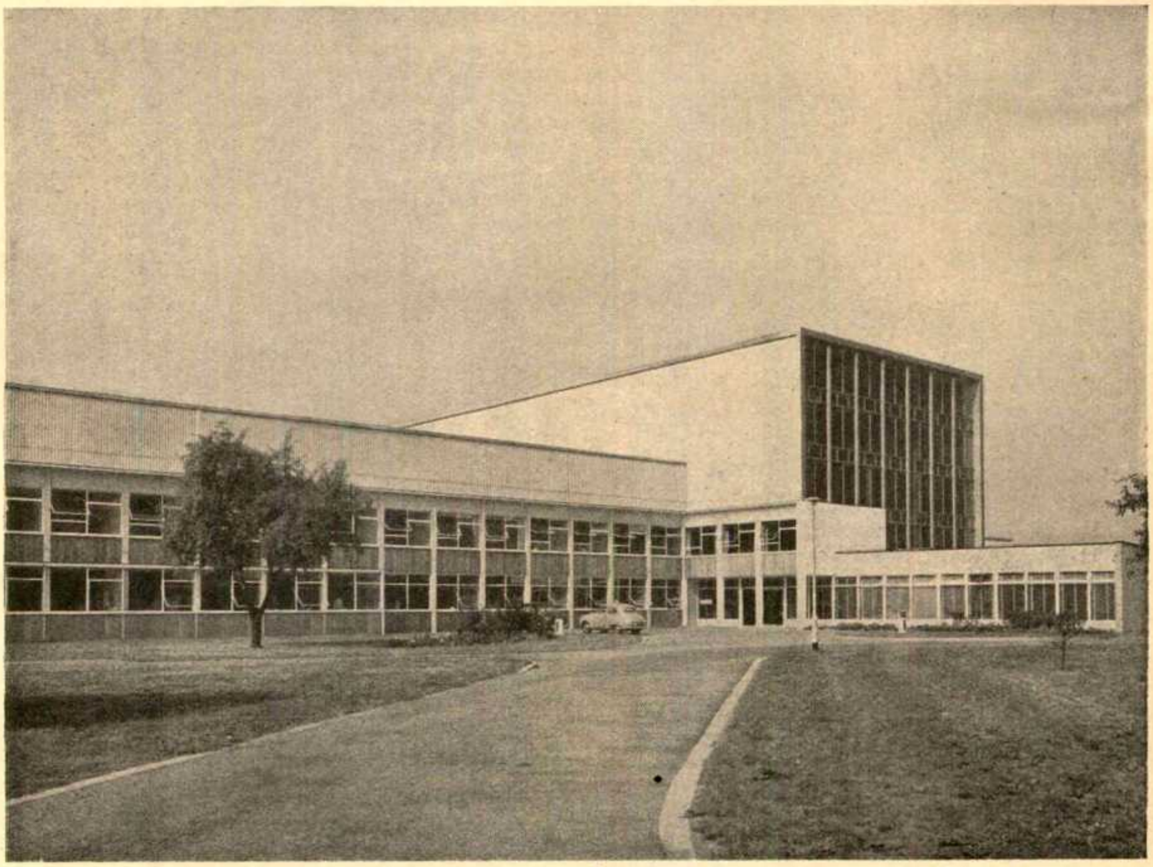

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Fig. 1. Ship Hydrodynamics Laboratory of the National Physical Laboratory

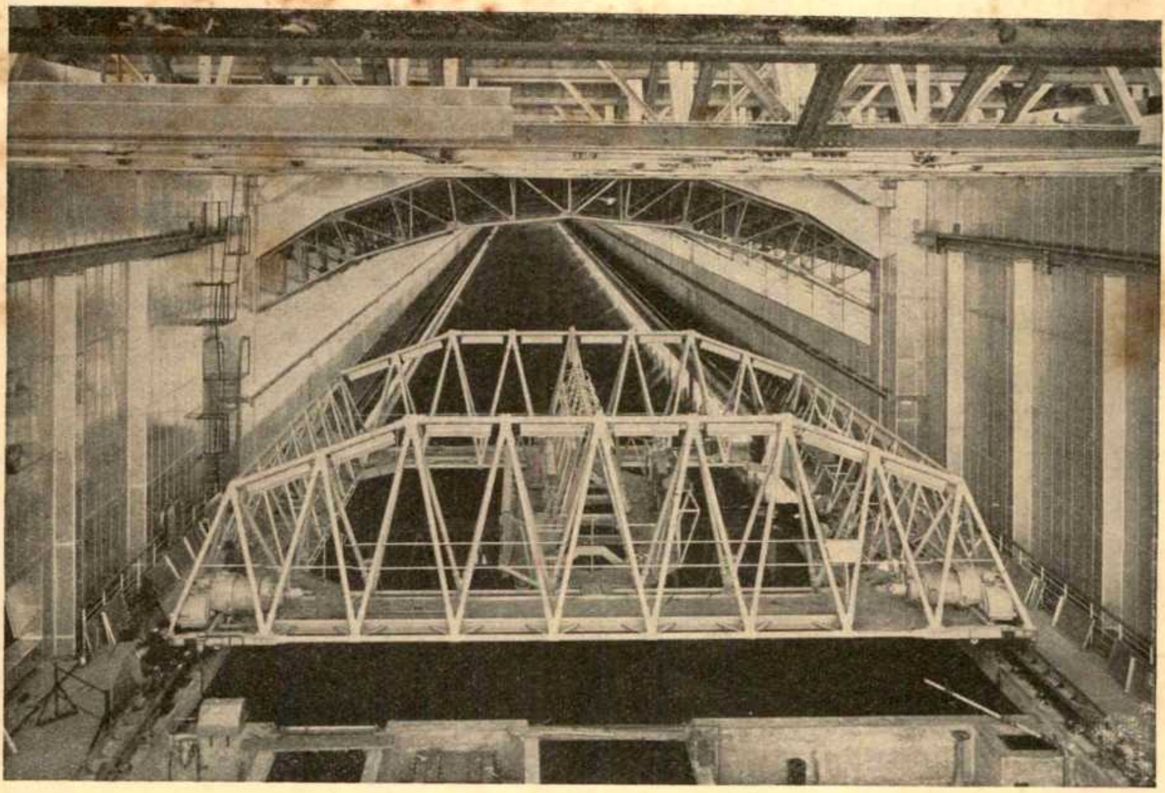
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Fig. 2. Carriage and main towing tank, 1,300 ft. long

The tank itself has been built of reinforced concrete sections. It is above ground-level, as the expense of keeping out the subsoil water would have been heavy in this area, where the water-table is very near the surface. Special care has been taken in the heating and ventilating arrangements to keep an even temperature in the building in order to maintain accurate rail alignment, avoid condensation effects on electrical equipment and ensure a reasonably constant nominal water temperature of 60° F.

The towing carriage (Fig. 2) is designed to tow ships' models up to 5 tons in weight and 40 ft. in length. The maximum speed attainable is 50 ft./sec., but this would not be used with heavy ship models. The carriage has four girders forming a square framework 50 ft. × 50 ft. externally, completely open inside, giving a space 36 ft. square. Into this centre space a fore and aft girder containing dynamometers and other instrumentation can be placed in a number of positions to give flexibility in carrying out different types of tests.

To decrease the effects of track deflexion and thus assist in providing undisturbed and uniform motion, the carriage is driven by four twin-wheel self-steering bogies on which the frame is in effect pivot-mounted via a system of rubber compression springs. Each bogie is powered by a 300 h.p. peak rating d.c. motor. The total peak power of 1,200 h.p. has been calculated to provide, with adequate margin, sufficient power to accelerate the carriage, which will weigh nearly 40 tons fully equipped, at the maximum rate without wheel slip. This value will have to be determined precisely by experiment, but will be of the order of $0 \cdot 1g$. Wind-tunnel tests have been made on a model of the carriage frame to help assess accurately the wind loadings at high speed.

The carriage is equipped with a speed-holding servo which will maintain any set test speed between 10 and 50 ft./s. within 0·1 per cent of the set speed. Much study has been given to the braking system necessary. The normal method of braking will be electrical, but at high speeds a system of mechanical friction brakes will be brought into use, which are spring operated and held off pneumatically so that they fail to safety in the event of loss of air supply. To limit the duration of the test run, track switches have been installed to bring on both electrical and mechanical brakes and bring the carriage to rest with a maximum deceleration rate of $0 \cdot 25g$. Should all these systems fail, an aircraft arrester gear has been fitted, with cables on each side of the tank. A shock-absorbing nylon harness on the underside of the carriage will engage hooks located on the inside face of the tank walls.

The investigation of the behaviour of vessels in a seaway demands the generation of regular and irregular wave systems in the tank. A wave-maker has been installed at one end of the tank capable of making waves up to 40 ft. in length and 2 ft. in height from crest to trough with an infinite variety of possible combinations within these limits. The wave-maker takes the form of a wedge-shaped plunger 17 ft. in height which spans the tank and tapers almost to a point at the bottom. The front face is curved to follow a theoretically ideal contour and is true to within $\pm \frac{1}{8}$ in. over the whole frontal area. The plunger moves vertically on slides on the end wall of the tank and is driven by hydraulic rams from a pump which operates normally on a sinusoidal pressure cycle to give a regular train of waves. By varying the pressure cycle it will be possible to generate irregular wave systems more typical of average ocean sea-states. To prevent reflexion of the waves from the other end of the tank, an end beach has been provided. This consists of a curved sloping surface, continuous below water and slotted in and above the water. It can be raised or lowered by means of buoyant chambers.

When tests are being made with a model in smooth water, she creates her own wave system, and time has to be allowed between successive runs to allow these waves to die down. In order to reduce this waiting time to a minimum, a similar beach is fitted in front of the wave-maker and can be raised to the surface when required. In addition, there are side beaches consisting of continuous lengths of curved flaps on either side of the tank which are hinged to the tank walls so that they can either be raised into a vertical position clear of the water when making waves or let down and partly submerged for still-water testing.

In long towing tanks the behaviour of models can be studied under conditions of head-on or stern-on waves. It has long been desired at the National Physical Laboratory to carry out tests in waves at different angles to the heading of the model and in confused seas and to investigate manœuvring qualities generally. This will now be possible at Feltham, with the new manœuvring and sea-keeping basin (Fig. 3), which is 100 ft. square with a depth of water of 8 ft. A plunger-type wave-maker has been fitted along one side capable of producing waves up to 15 ft. long and 9 in. high. A beach has been fitted on the opposite side. It is intended later to fit another wave-maker on an adjacent wall, and this may be articulated, to enable confused seas to be generated.

Models up to 10 ft. in length can be used in this tank, and as they are to be free-running, they must carry their own source of power and instrumentation. They must therefore combine lightness with strength, and will in general be made of fibre-glass plastic. They will be radio-controlled from shore, and the instrumentation in the models will either record its own data or telemeter them ashore. The Control Mechanisms and Electronics Division of the Laboratory is assisting in the development of a tracking system.

The new water tunnel (Fig. 4) is intended primarily for research work on propellers up to 24 in. in diameter and can also be adapted for testing hydrofoils and similar bodies. This work is likely to grow in importance with the increasing demand for high speeds in ships of all classes. The tunnel is one of the largest of its type, with a circular closed test section 44 in. in diameter; it is designed for a maximum water velocity in the working section of 50 ft./s.

The tunnel shell is arranged as a rectangular circuit of which the upper horizontal limb is at ground-level. This portion includes the contraction section, where the water is accelerated to the working-section velocity, the working section itself and the transition and diffuser sections, where the speed of the water is gradually reduced before entering the suction side of the pump. The remaining portions of the tunnel form a U-shaped circuit descending 180 ft. into the ground and forming a 'resorber'. This is designed to subject the water to an additional static pressure-head during transit, when all bubbles created by cavitation at the model and released into the water stream are re-absorbed into solution.

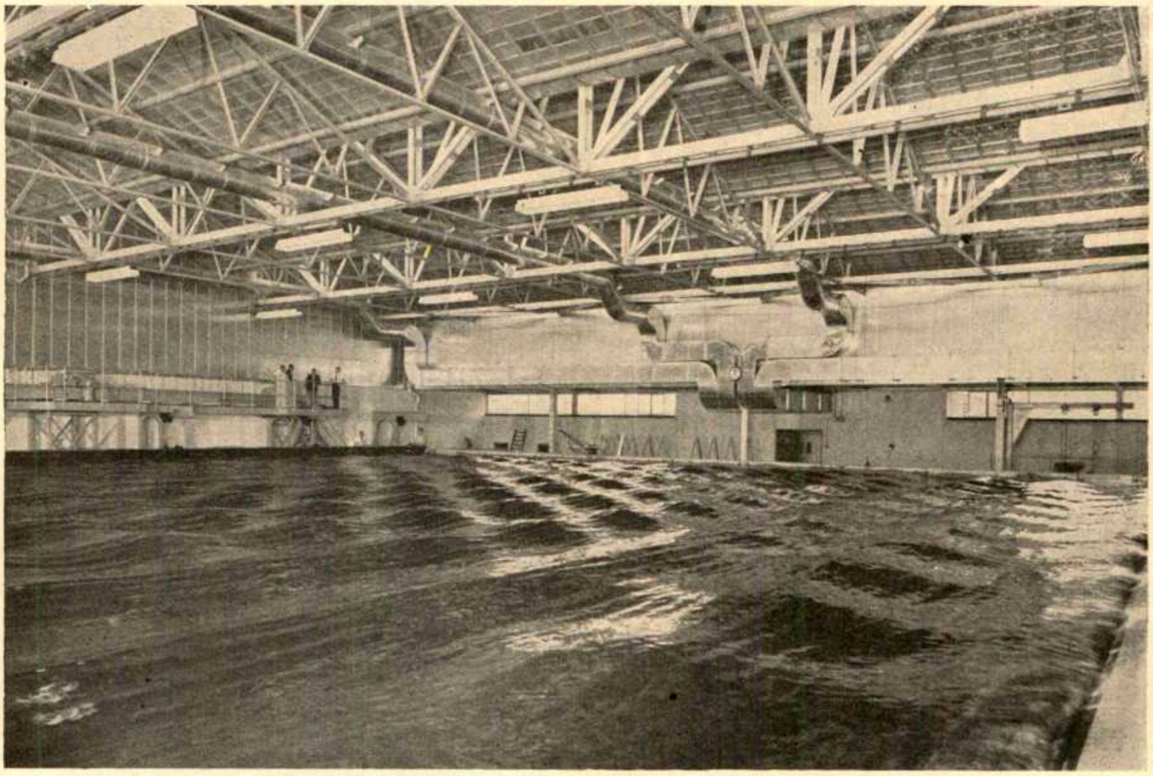

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Fig. 3. Sea-keeping tank

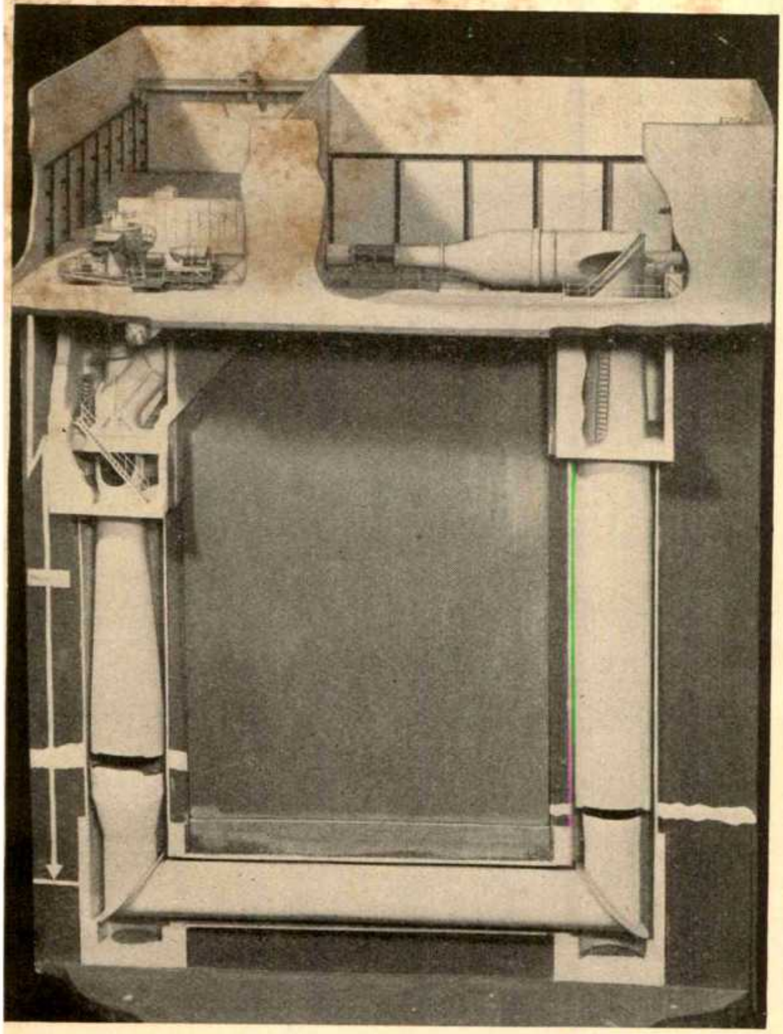

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Fig. 4. Model of the water-tunnel showing underground portion

The water will be circulated around the tunnel by a 92-in. diameter vertical variable-pitch pump driven at a maximum speed of 220 rev./min. by an 850 h.p. mean continuous rating vertical d.c. motor, which is equipped with automatic speed-holding equipment designed to hold any set speed with an accuracy of 0·1 per cent.

The model propeller is mounted on a downstream shaft, fitted with thrust and torque dynamometers and driven by a 300 h.p. motor. The pressure in the test section can be varied from near zero to 6 atmospheres absolute. The tunnel is fitted with stroboscopic lighting and high-speed photographic equipment.

There are a number of small laboratories devoted to the development of new instrumentation, a photographic room and a vibration laboratory containing a water tank 20 ft. by 14 ft. and 6 ft. deep for experiments on virtual mass and similar problems.

The Laboratory is fully equipped with workshops for making wax, wood and plastic hull models, and casting and finishing propeller models in bronze. The office block includes a handsome library, a dining room and kitchens. The offices and workshops have been occupied since August 1958, and much of the new instrumentation has been built in the shops.

The new Ship Hydrodynamics Laboratory will be under the personal direction of Dr. F. H. Todd, superintendent of the Ship Division of the National Physical Laboratory.

LOCALIZATION AND ASSAY OF RESPIRATORY ENZYMES IN SINGLE LIVING CELLS

Absorbancy Measurements on the *Nebenkern*

By Dr. ROBERT P. PERRY*, Dr. Bo THORELL, Dr. LENNART ÅKERMAN
and Prof. BRITTON CHANCE

Johnson Research Foundation, University of Pennsylvania, Philadelphia, Pennsylvania,
and Department of Pathology, Karolinska Institute, Stockholm

A STUDY and selection of appropriate optical, electronic, and photoelectric components now permits remarkable sensitivity in the detection of small changes of absorbancy caused by enzyme reactions in living materials. In the case of suspensions of whole cells or cell particles, a detectability of 10^{-11} mole can be achieved without difficulty in a 1-c.c. cuvette of a recording spectrophotometer[1]. Microspectrophotometry affords an even more favourable situation for the study of small amounts of biological materials in that measurements can be localized to specific parts of single living cells, and the cells themselves may be selected on the basis of temporal or morphological criteria. Hitherto, however, it has been used mainly for the evaluation of substances present in relatively high concentrations, such as proteins and nucleic acids[2], and for studies of the formation of hæmoglobin in erythroid cells[3,4]. So far only limited success has been had in measuring those pigments of the single cell which are present in 'enzyme' concentrations, since this requires sensitivities in measuring changes of absorbancy between one-tenth and one per cent over an aperture of about a micron.

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This communication reports the application of a combination of a highly sensitive recording circuit and the microscopic technique[5] which permits the assay of the cytochromes localized in single mitochondrial aggregates, particularly the 5-μ diameter *Nebenkern* of grasshopper spermatids, with an accuracy of several per cent. This sensitivity allows the detection of 10^{-20} mole or 6,000 molecules of the cellular enzyme, cytochrome *b*. The following communication describes localized measurement of the fluorescence of pyridine nucleotide of the *Nebenkern* and that of mitochondrial aggregates of other types of cells with a sensitivity comparable to that of this instrument.

The optical system used is similar to that described by Thorell and Åkerman[4]. It employs a 250-mm. focus, grating monochromator, a 1·6-mm. Grey reflecting water-immersion condenser and objective (N.A. = 1·0), and a 3·5 × quartz ocular which projects the beam on to a vibrating mirror assembly. The photomultiplier is type 1*P*28 and operates in the range of total voltage 400–650 V. The tungsten lamp is given an overvoltage of approximately 30 per cent to provide adequate illumination. The spectral interval of the monochromator is approximately 3 mμ. The amplitude of the vibrating mirror corresponds to approximately 12μ. The hole in front of the photocell corresponds to a 1·5-μ diameter aperture.

The electronic circuit incorporates the dynode feedback circuit of Picard[6] as previously used by Yang[7] and Åkerman[8]. The circuit is insensitive to grid and dark currents, and will operate at very low signal-to-noise ratios due to a switching circuit that adds a signal to the phototube output exactly equal to that of the reference signal (~ 1 V.). Thus the output wave-form consists of alternate pulses: reference beam, dark, measuring beam, dark, in a balanced wave-form with no 'pips' for equal reference and measurement signals (Fig. 1). This signal can be highly amplified without amplifier overload and demodulated to give appropriate signals for control of the dynode voltage (reference minus dark) or measurement of absorbancy (reference minus measure). The noise-level of the spectrophotometer at 420 mμ is about 10^{-4} in optical density units with a 2·5-sec. time constant.

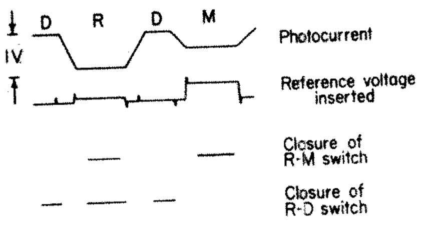

Fig. 1. Wave-form diagram illustrating the principle of operation of the electronic circuit of the microspectrophotometer. As indicated in the left-hand scale, the amplitude of the wave-form is slightly less than 1 V. The top trace represents the wave-form of the photocurrent after electron amplification. The portions labelled *D* are those corresponding to the dark interval and those labelled *R* and *M* refer to the intervals during which the light passes through the material in the reference and measuring areas. The second trace represents the wave-form after 1 V. has been inserted into the wave-form at intervals *R* and *M*. A measurement of the absorbancy difference between the *R* and *M* optical paths is made by a closure of the *R* – *M* switch. Control of the dynode voltage for the photocell in response to any deviation of the *R* – *D* difference from 1 V. is measured by the closure of the *R* – *D* switch (*MD* – 82)

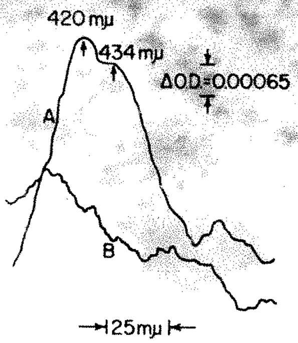

Fig. 2. Spectrum of anaerobic spermatid. Trace *A* represents the difference of absorbancy between the *Nebenkern* and the adjoining free space. Trace *B* represents the difference between the cytoplasm of the cell and the adjacent free space. The recording is on a linear wave-length scale (*RP* – 1)

Spermatid preparations were made from mature grasshoppers by Belar's method[9]. The cells were confined between a slide and coverslip suspended in about 3 μl. of buffer. Aerobic conditions were obtained in glucose-free suspensions for approximately 1½ hr. observation. Thereafter cell respiration exhausted the oxygen and the material contained in the suspension became anaerobic. By this simple method it was possible to obtain, in one experiment on a single *Nebenkern*, spectra corresponding to the oxidized and reduced forms of the cytochromes. If glucose was added to the buffer, anaerobic conditions were attained a few minutes after preparation. The anaerobiosis was monitored by the inclusion of some human erythrocytes under the coverslip, and the time of anaerobiosis was checked from measurements of the characteristic shift of the hæmoglobin absorption bands[4].

Fig. 2 shows two traces obtained from a single anaerobic spermatid in a preparation treated with glucose. Curve *A* illustrates the absorbance of the *Nebenkern* measured with respect to the surrounding free space; curve *B* records the absorbance of the cytoplasm of the spermatid, also with respect to the surrounding free space. The *Nebenkern* shows an absorption maximum at 420 mμ with a distinctive shoulder at 434 mμ.

Observations of the *Nebenkern* in a glucose-free suspension 70 min. after closing the preparation with a coverslip show a single peak at approximately 413 mμ, such as that shown in Fig. 3. Other experiments in which the spermatid respiration was inhibited by iodoacetate show, for a considerable interval, the single peak characteristic of the cytochromes, mainly in the oxidized state.

The measurement of the *Nebenkern* under aerobic or anaerobic conditions invariably gives clear Soret

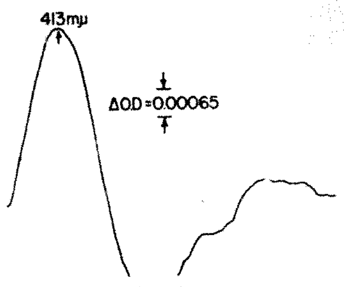

Fig. 3. Spectrum of aerobic spermatid, *Nebenkern* versus nucleus. Spectrum recorded 70 min. after preparation of glucose-free material (*RP* – 6)

peaks 413 mμ for aerobic conditions and 420 and 434 mμ for anaerobic conditions These are almost identical with the theoretical composite curves constructed from the known spectra of reduced or oxidized cytochromes *a*, a_3, *b*, and *c* mixed on an approximately equimolar basis Preliminary attempts have been made to examine the alpha bands of the cytochromes, but inadequate sensitivity is available with the light intensity, photosensitivity, and response times used at present However, some encouraging preliminary results have been obtained with liver cells, as described in the third communication of this series

The curves of cytoplasm or nucleus versus free space are monotonic functions which may show a systematic deviation corresponding to about 2×10^{-3} optical density units per 100 mμ change of wave-length The direction of the shift is variable and depends upon the combination of instrumental error and differences of light-scattering in the specimen

Errors due to the motion of the cell can be readily observed and precautions are taken to record only those cells which are immobilized at the glass surface by surface tension or are entangled in the tails of mature sperm The error due to motion can be negligible under favourable conditions compared to the intrinsic noise of the spectrophotometer The average reproducibility for several curves is approximately 3×10^{-4} optical density units.

The remarkable absorption of the *Nebenkern* and the lack of any significant absorption, in this wave-length range, of the cytoplasm give direct support to the current idea that the bulk of the respiratory activity is associated with the mitochondrial bodies The experiments reported here show that the *Nebenkern* contains *in vivo* at least 50 times more cytochromes per unit volume than any other comparable part of the cell

An estimate of the concentration of cytochrome in the single *Nebenkern* based upon these data (Δ O D at 425–430 mμ = 5×10^{-3}), an extinction coefficient of reduced cytochrome *b* of 160 cm $^{-1}$ mM^{-1}, and an estimate of 60 per cent contribution of cytochrome *b* to this peak, gives an effective concentration of 36 μmoles per litre over a 7 5 μ^3 volume of the *Nebenkern* Assuming equimolar amounts of the four principal cytochromes, the total cytochrome concentration is 144 μmoles per litre or about 10^5 molecules per μ^3 If the difference of optical density is expressed in terms of the amount of cytochrome *b* in a 7 5-μ^3 volume, one obtains 5×10^{-19} mole or 30,000 molecules Since the signal-to-noise ratio is about 50 1, the error in detection corresponds to 10^{-20} mole or 6,000 molecules This value compares very favourably with that obtained by any other method for the determination of the amount of an enzyme concentration *in vivo*

This investigation was supported in part by grants from the National Science Foundation, the U S Office of Naval Research, and the Swedish Medical Research Council

[1] Chance, B , *Science*, **120**, 767 (1954)

[2] Caspersson, T , *J Roy Micro Soc* , **60**, 8 (1940)

[3] Thorell, B , Ciba Foundation Symposium on Porphyrin Biosynthesis and Metabolism, 174 (London, 1955)

[4] Thorell, B , and Åkerman, L , *Exp Cell Research*, Supp , **4**, 83 (1957)

[5] Chance, B , Perry, R , Åkerman, L , and Thorell, B , *Rev Sci Instr* , **30**, 735 (1959)

[6] Picard, R G , *RCA* Report

[7] Yang, C C , *Rev Sci Instr* , **25**, 807 (1954)

[8] Åkerman, L (in preparation)

[9] Belar, K , *Arch Entwickl Organismen*, W Roux, editor, **118**, 359 (1929)

Fluorescence Measurements of Mitochondrial Pyridine Nucleotide in Aerobiosis and Anaerobiosis

By Prof BRITTON CHANCE

Johnson Research Foundation, University of Pennsylvania, Philadelphia, Pennsylvania

AND

Dr Bo THORELL

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SPECTROSCOPIC observations of the large pyridine nucleotide content of isolated mitochondria[1] were recently supplemented by the demonstration of the intensified and shifted fluorescence of this substance in mitochondria[2] These results direct attention to the possibility of a close relationship between the blue autofluorescence of the living cells and that of the reduced pyridine nucleotide component of the mitochondria[1–6] This communication describes photoelectric measurements of fluorescence of mitochondrial bodies in the grasshopper spermatocyte The localization of blue fluorescence in mitochondrial aggregates has been demonstrated, and quantitative measurements of the kinetics of changes in response to aerobiosis and anaerobiosis have been made A comparison of the fluorescence of mitochondrial aggregates and the neighbouring cytoplasm during this change from aerobiosis to anaerobiosis may lead to a much clearer understanding of the dynamics of interaction of the cytoplasmic and mitochondrial pyridine nucleotide *in vivo* While the present technique has been applied only to cells showing large mitochondrial aggregates, the excellent performance obtained under these conditions may allow the study of much smaller numbers of mitochondria The combination of this instrument for measuring the mitochondrial pyridine nucleotide with that of a sensitive microspectrophotometer (see preceding communication) for the study of the cytochromes may provide a new method for following metabolic changes in cytologically defined parts of the living cell

The 1,000-watt, *AH*6 mercury arc illumination was filtered by means of a water-cooled Corning 584 filter (Marshall, personal communication), and by an 'Eppendorf' 366 mμ multi-component filter. Dark-field cardioid illumination of the sample was observed through a 100× adjustable aperture lens set at N A = 1 00 and a 10× ocular A 60-c /s. vibrating diaphragm[7] with an effective 5-μ aperture sweeps through an effective distance of 15μ and allows comparison of the intensity of fluorescent portions of the cell and the adjacent free space by means of an electron multiplier photocell The intensity of the a c -operated mercury lamp reaches a maximum at the excursions of the vibrating diaphragm (see Fig 1) Simultaneously, an electronic switch communicates signals to a storage condenser so that the difference of the intensities at the peaks of

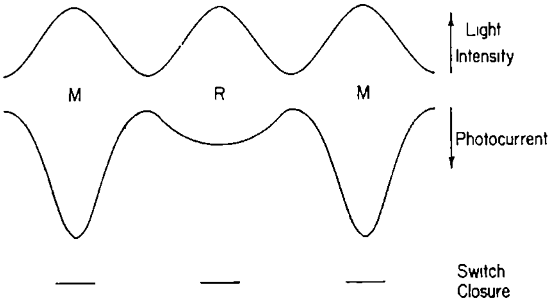

Fig 1 Wave-form diagram indicating the time relations of the light intensity, photocurrent, and switch closure for the microfluorimeter The top line represents the time-variation of the intensity of the mercury arc lamp The modulation frequency is 120 c /s , and the amplitude of modulation is nearly 100 per cent The second wave-form is that of the photocurrent after electron amplification (An increase of current is indicated by a downward deflexion) This wave-form is in response to a fluorescent object in the *M* position of the aperture, and the surrounding free space in the *R* aperture , the distance between *M* and *R* is approximately 15μ As indicated at the bottom of the trace, the closure of a synchronized mechanical switch is coincident with the peak of the *M* and *R* wave-forms The electronic circuit measures the difference between the amplitudes of the photocurrent at the *M* and *R* intervals (*MD* – 83)

the excursions of the diaphragm are recorded by a millivoltmeter, the sensitivity of which is 1 mV for 10^{-16} amp of primary photocurrent The average signal from the mitochondrial aggregate or *Nebenkern* (4×10^{-16} amp) gives a signal-to-noise ratio of the order of 30 1 with a time constant of about 2 sec

Localization of fluorescence in grasshopper spermatid Fig 2*a* represents recordings of fluorescence intensity as a function of time for two positions of the measuring aperture with respect to the cell At the left of the graph, the abrupt downward deflexion of the trace indicates opening of the photocell shutter and the maximal downward deflexion corresponds to the intensity of fluorescence of the *Nebenkern* measured with respect to the free space surrounding the cell By an adjustment of the air pressure on the movable stage[8] the cell is moved so that one aperture coincides with the cytoplasm Here a 50 per cent diminution of the intensity is noted The specimen (moved a distance of about 5µ) is then returned to its initial position so that the *Nebenkern* again coincides with the aperture, and the previous value of fluorescence intensity is obtained The record ends with the closing of the shutter In this way the fluorescence intensities of different portions of the cell can be scanned A schematic diagram of such a study (Fig 2*b*) indicates intensity measurements corresponding to the free space, cytoplasm, and *Nebenkern*, the width of the rectangles corresponding to the half-power response of the measuring aperture These results suggest that the fluorescence of the cell is highly localized in the *Nebenkern* body

The study of many anaerobic spermatids having *Nebenkern* indicates that the ratio of the fluorescence signal of the *Nebenkern* to that of the cytoplasm varies from a minimum of 1 7 1 to a maximum of 6 1, the average for ten cells being 3 3 1 The variation of these values may be due to a number of factors , for example, the position of the *Nebenkern* or the thickness of the cytoplasm in which a measurement is being made or the metabolic state of the spermatid A significantly higher fluorescence has been observed in the nucleus than in the cytoplasm, values ranging as high as 2 1 However, the biochemical significance of fluorescence other than that of the *Nebenkern* requires studies of its biochemical response to different oxidation-reduction conditions as described below

Biochemical response of the intensity of fluorescence In order to subject the *Nebenkern* of the living cell to a metabolic change which would specifically identify its fluorescence with that of mitochondrial reduced pyridine nucleotide of the respiratory chain, we have followed its time course in the transition from aerobiosis to anaerobiosis (see Fig 3) As described in the preceding communication, glucose-free spermatids will exhaust the oxygen under a coverslip in about 90 min In the microfluorimeter, a coverslip of smaller diameter and a smaller liquid volume are used It is calculated that anaerobiosis can be expected in about 40 min The right-hand portion of Fig 3 (open circles) shows the fluorescence as a function of the time after excluding air from the preparation The fluorescence of the *Nebenkern* rises slowly for 40 min and then abruptly until a total of 60 min has elapsed Thereafter, the fluorescence of the *Nebenkern* is constant Measurements of the cytoplasmic fluorescence (solid circles) indicate no rise of fluorescence over the 90-min interval and there is some indication of a slight decrease In order to avoid prolonged ultra-violet radiation of a particular cell, three cells were studied in the course of the experiment and they are identified by the numbers along the abscissa In order to diminish instrumental error and any differences between the cells which might contribute an error to the right-hand portion of the figure, the results are plotted in the left-hand portion in terms of the ratio of the *Nebenkern* fluorescence to the cytoplasmic fluorescence , it is seen that the fluorescence increases slowly for the first 40 min , and then rises abruptly between 40 and 55 min to reach a plateau which is maintained thereafter This behaviour is characteristic of the transition from the oxidized to the reduced state of mitochondrial pyridine nucleotide in the transition from aerobiosis to anaerobiosis[1,2,9]

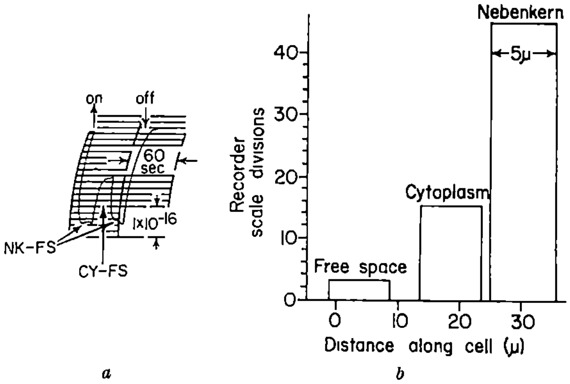

Fig 2*a* An example of the measurement of the fluorescence intensity of two portions of the grasshopper spermatid under anaerobic conditions The phototube shutter is opened and closed at the points labelled 'on' and 'off' The time scale runs from left to right , the initial reading is made with the measuring aperture on the *Nebenkern* and the reference aperture on the free space (*NK–FS*) The specimen is then moved 5μ by means of a flexible quartz plate, after which the tracing records the fluorescence intensity of the cytoplasm (*CY–FS*) The specimen is then returned to the initial position (*NK–FS*) and the shutter is closed The scale indicates the primary photo-current (1×10^{-16} amp per 5 scale divisions) (925*a*)

Fig 2*b* Scan of fluorescence intensities of anaerobic grasshopper spermatid The cell is moved with respect to the measurement aperture by means of the flexible quartz plate and positions are chosen with the measurement aperture on the free space, cytoplasm, and *Nebenkern* The cell boundary is approximately at the 10μ position on the scale of the abscissa (920*a*)

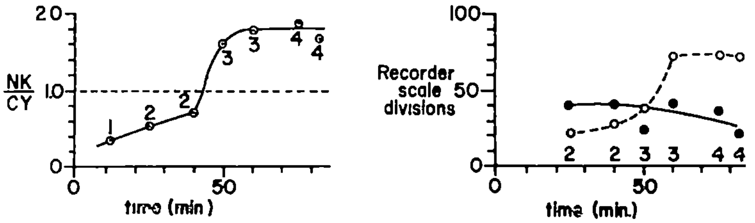

Fig 3 Time-course of the fluorescence changes of the *Nebenkern* (open circles) and the cytoplasm (solid circles) of a grasshopper spermatid during the aerobic–anaerobic transition On the right, the independent determinations in the cytoplasm and on the *Nebenkern* are plotted, on the left, the ratios of the two measurements The abrupt discontinuity at 45 min corresponds to the expected time for the exhaustion of oxygen under the coverslip The numbers adjacent to the circles refer to the cell which is under observation (922*a*,*b*)

These results appear to identify the *Nebenkern* fluorescence with that of reduced pyridine nucleotide If we assume that the cytoplasmic fluorescence is also due to pyridine nucleotide, these results suggest that there is no rapid change of the oxidation-reduction state of cytoplasmic pyridine nucleotide of the grasshopper spermatid associated with the aerobic–anaerobic transition

Studies of other cells Cells which do not show a distinctive localization of mitochondria, as does the grasshopper spermatid, do not permit a distinction between cytoplasmic and mitochondrial fluorescence However, in the anaerobic state, the greater fluorescence of mitochondrial material would lead at least to a preponderance of mitochondrial effects For example, observations of the effects of the transition from aerobiosis to anaerobiosis can be observed by measurements of the brighter portions in the cytoplasm of ascites tumour cells In these cells, the fluorescence is constant for about 10 min, rises for an interval of 10 min and then remains approximately constant (Fig 4) A comparison of this graph with the right-hand portion of Fig 3 (open circles) shows that the percentage increase is considerably less for a cell in which both cytoplasmic and mitochondrial fluorescences are summed, in fact, a curve similar to that of Fig 4 can readily be constructed from the results of Fig 3 if one plots the sum of mitochondrial and cytoplasmic fluorescence as a function of time

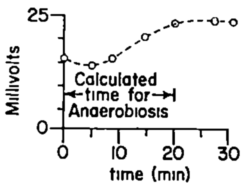

Fig 4 Time-course of the fluorescence changes of an ascites tumour cell during the aerobic–anaerobic transition The recording is taken from what appears to be a mitochondrial aggregate in the cytoplasm of the cell 'Calculated time for anaerobiosis' represents the number of minutes it should have taken the suspension to become anaerobic, if the respiratory-rate measured in the bulk phase were valid for the microscopic sample (929*a*)

It would appear therefore that, in spite of the inferior localization obtained with the ascites tumour cells, substantially the same results are obtained in the aerobic–anaerobic transition Similar results have been obtained for pentaploid yeast cells and preliminary studies of the application of this method to the kinetics of transfer of mitochondrial material from the mother to the daughter cell in budding yeast have been made

Discussion The blue autofluorescence of living cells and tissues has been indirectly associated with mitochondrial bodies by Sjostrand[3], who has studied in detail the fluorescence characteristics of thiamin and frozen dry sections of axons and of riboflavin in acid-treated groups of kidney cells (Sjostrand, unpublished work) However, no detailed investigations of the fluorescence of the living tissue were possible due to its relatively lower intensity Independent developments in the study of fluorescence of solutions of reduced pyridine nucleotide by Boyer and Theorell[4] and by Duysens and Kronenberg[6] have shown a characteristic shift and an enhancement of this fluorescence in the presence of enzymes which will bind the coenzyme The peak of this fluorescence is approximately 443 mμ Duysens and Amesz[5] have recorded a similar fluorescence in suspensions of yeast cells Spectroscopic observations of the high content of pyridine nucleotide in isolated mitochondria[1,9] have led to a study of their fluorescence[2] Here again a maximum at 443 mμ is obtained, suggesting that the reduced pyridine nucleotide of the mitochondria is in a bound form, and therefore that the blue autofluorescence of mitochondria of living cells may well be associated with its bound reduced pyridine nucleotide The experiments reported here verify the localization of a fluorescence characteristic of reduced pyridine nucleotide in the mitochondrial aggregate of the grasshopper spermatid and also show that it has excitation and emission characteristics which are not inconsistent with those of reduced pyridine nucleotide However, the following kinetic data give the most direct support for this supposition

First, the change of fluorescence in the grasshopper spermatid occurs at the time expected for anaerobiosis in view of the calculated respiratory activity of the cells Second the change of fluorescence is an increase, as expected from studies of suspensions of mitochondria or intact cells, that is, where increased reduction of pyridine nucleotide occurring in the aerobic–anaerobic transition leads to increased fluorescence of intramitochondrial pyridine nucleotide Thirdly, the fact that the *Nebenkern* shows some fluorescence in the aerobic state is consistent with the observation of a partial reduction of pyridine nucleotide in the steady state of metabolism, provided substrate is present Thus, reduced pyridine nucleotide could readily account for nearly all the fluorescence of the *Nebenkern* This confirms observations of suspensions of liver mitochondria in which complete oxidation of intramitochondrial pyridine nucleotide removes the bulk of fluorescence that is excited in the wave-length region 340–366 mμ (ref 2)

The fact that fluorescence of the *Nebenkern* is considerably less than that of the cytoplasm in the aerobic cell and increases to a value considerably greater than in the anaerobic cell is also significant Since pyridine nucleotide is present in the cytoplasm, and may well be bound to dehydrogenases and hence have shifted and intensified fluorescence, it appears reasonable to attribute the cytoplasmic fluorescence, at least in part, to this substance On this basis we conclude that a change in the oxidation-reduction state of the mitochondrial pyridine nucleotide by a factor >3 has no measurable effect upon that of the cytoplasm this is a demonstration *in vivo* of the phenomenon of impermeability of mitochondria to reduced pyridine nucleotide While this phenomenon has been accepted on the basis of *in vitro* experiments[10], the possibility existed that the impermeability of the mitochondrion may have been acquired during isolation, for example, by its envelopment in the endoplasmic reticulum (ref 11, also personal communication) Within the framework of the assumptions here, we can put forward evidence, at least for the grasshopper spermatid, of the unreactivity of the mitochondrial membrane to cytoplasmic pyridine nucleotide *in vivo* This observation is of considerable importance in the study of metabolic control and in the dynamics of interaction of intracellular bodies[12] In cells that fail to show the extent of mitochondrial aggregation observed in the *Nebenkern*, we are at present unable to give further data on this point

Our thanks are due to Dr R P Perry for advice and criticism, and to Miss Georgann Cullen for assistance in these studies

This investigation has been supported in part by grants from the Office of Naval Research and the National Science Foundation

[1] Chance, B , and Williams, G R , *J Biol Chem* , **217**, 395 (1955)
[2] Chance, B , and Baltscheffsky, H , *J Biol Chem* , **233**, 736 (1958)
[3] Sjostrand, F S , *Acta Anat* , Supp 1, 1 (1944)
[4] Boyer, P D , and Theorell, H , *Acta Chem Scand* , **10**, 447 (1956)
[5] Duysens, L N M , and Amesz, J , *Biochim et Biophys Acta*, **24**, 19 (1957)
[6] Duysens, L N M , and Kronenberg, G H M , *Biochim et Biophys Acta*, **26**, 437 (1957)
[7] Chance, B , and Legallais, V , *Rev Sci Instr* , **30**, 732 (1959)
[8] Caspersson, T , *J Roy Micro Soc* , **60**, 8 (1940)
[9] Chance, B , and Williams, G R , *J Biol Chem* , **217**, 409 (1955)
[10] Lehninger, A , "The Harvey Lectures", Series XLIX, 1953–54, p 176 (1955)
[11] Palade, G E , and Siekevitz, P , *J Biophys Biochem Cytology*, **2**, 171 (1956)
[12] Chance, B , and Hess, B , *Science*, **129**, 700 (1959)

Absorbancy Measurements on Liver and Kidney Cells

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IN the multicomponent reaction system of the living cell, the organization and spatial distribution of the different enzymes are of fundamental importance During the past decade, much data have been obtained about the localization of enzymes in various cellular structures A further step towards a more integrated and physiologically adequate picture of the cell functions can be made if these enzyme systems are studied *in situ*

This communication reports the localization and assay of respiratory enzymes (cytochromes) in areas of 1 5μ diameter in the cytoplasm of single, living rat liver and kidney cells under different external conditions as regards the oxygen tension, namely, under aerobic and anaerobic states The analyses were made by recording the specific light absorption (magnitude about 1 per cent) in the Soret wave-length region with the highly sensitive microspectrophotometer outlined in the first communication of this group

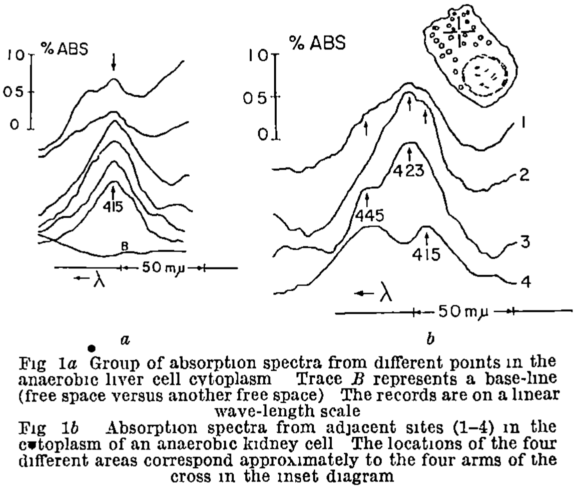
Single parenchyma cells from the liver or kidney-cortex of adult Wistar rats were teased out in a drop of Krebs–Ringer solution on a microscope slide with a small scalpel and a needle After a coverslip had been put on, the cells were washed with a few drops of Krebs–Ringer solution sucked through the preparation by a piece of filter paper To obtain anaerobiosis, ethanol-treated, starved yeast cells were incorporated in the preparation prior to sealing it with paraffin wax around the coverslip edges Without the yeast, aerobic conditions of the cells were obtained for several hours The state of each preparation was checked by measurement of the hæmoglobin absorption bands in some added human erythrocytes[1]

The microspectrophotometer is described in detail elsewhere[2] The microscope optics were a 1 6 mm Grey reflecting water-immersion condenser and 1 0 N A objective A 3 5 × quartz ocular projected the image via a vibrating mirror assembly[1] on to the photomultiplier aperture The location of the cell image on the light-receiving system was controlled by means of an interchangeable cross-hair The areas in the cell selected for absorption measurements were 1 5μ in diameter The 'reference area' in the preparation was at a distance of 12μ from the measurement area and care was taken to choose as clear a space as possible to provide 'absolute' spectra

On the light-absorption records obtained, an empirical wave-length calibration was made by tracing the 415-mμ maximum of the erythrocyte oxyhæmoglobin with the identical wave-length scanning speed and time constant as in the other measurements In this way the cytochrome absorption maxima could be estimated within ± 2 mμ

Figs 1*a* and *b* show typical sets of absorption curves from points in the cytoplasm of single liver and kidney cells, where the anaerobic state was ensured by the presence of respiring yeast cells In the various curves three distinctive absorption maxima or 'shoulders' appear at 415, 423 and 445 mμ

If the yeast cells were omitted and the density of the rat parenchyma cells was low enough to permit the aerobic state during several hours, the changes in the state of the respiratory enzymes could be



a *b*

Fig 1*a* Group of absorption spectra from different points in the anaerobic liver cell cytoplasm Trace *B* represents a base-line (free space versus another free space) The records are on a linear wave-length scale

Fig 1*b* Absorption spectra from adjacent sites (1–4) in the cytoplasm of an anaerobic kidney cell The locations of the four different areas correspond approximately to the four arms of the cross in the inset diagram

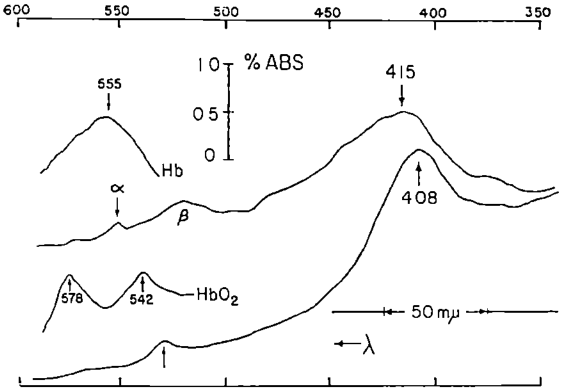


Fig. 2. Spectra from an area of 1·5μ diameter in a liver-cell cytoplasm during the aerobic (bottom record) and subsequent anaerobic (top record) states. The second spectrum was recorded after an interval of 30 min., during which the hæmoglobin absorption of an adjacent human erythrocyte shifted as shown by the two left-hand records

recorded within the same, single cell. Fig. 2 shows such an experiment, in which the hæmoglobin absorption of an adjacent erythrocyte was also recorded. The reduction of the red cell hæmoglobin, which in this particular experiment preceded by about 20 min. the absorption changes in the intracellular cytochromes, indicated that the oxygen concentration in the medium was less than 20×10^{-6} mole per litre.

The results show that absorption bands of the hæmoprotein type can be obtained from small areas ($d = 1·5\mu$) in the single intact mammalian cell. The shift in the absorption maxima which occurred parallel with changes in the oxygen tension indicates that the specific absorptions are due to respiratory enzymes. The orders of magnitude of the absorptions measured in the single liver cell (about 1 per cent) are the same as can be calculated theoretically for cytochromes[3,4].

If the spectra obtained from the single intact cells are compared with the spectra of purified cytochromes, the main peaks at 408_{ox} and 415_{red}, 423_{red} and 445_{red} will correspond to the Soret absorption bands of cytochrome *c*, *b* and *a* respectively.

The strictly quantitative interpretation of the absorption spectra from such optically inhomogeneous materials as liver and kidney cells is more difficult than in the case of the geometrically uniform *Nebenkern* (see first communication). The obviously multicomponent curves in Fig. 1*b* were obtained within a very small optical cross-sectional area (about $2 \times 1·5\mu^2$). The different proportions of the components found at adjacent sites can be explained either by the presence of structures containing varying proportions of cytochromes, or by changes in the layering of a few distinct structures along the microspectrophotometric light-path through the cell.

If the present *in vivo* microspectrophotometric results are compared with the data on enzyme distribution obtained from the bulk isolation of cellular components, some apparently contradictory points emerge. The rather pronounced absorption band 408_{ox}–415_{red} in practically every part of the liver cell cytoplasm indicates large amounts of a cytochrome unlike b_5. The same absorption bands are also present in the large particle-free homogeneous cytoplasmic area ('endoplasm') of the ultra-centrifuged but otherwise intact liver cell[5]. Cytochrome b_5, which can be isolated from the 'microsomal' liver-cell fraction, has bands (413_{ox}–423_{red})[3]. Different explanations for this discrepancy can be put forward: for example, that the isolated 'microsomal' fraction might constitute only a minor part of the 'endoplasm' and that a cytochrome might have been lost during the isolation procedure. Some support for the existence of a difference between the spectral character of the DPNH-reducible pigments and that of the isolated microsomes is emerging from studies of suspensions of liver cells (Chance and Rutter, unpublished observations). In any event, the studies reported here underline the importance of structural interpretations of absorption spectra obtained microspectrophotometrically from the highly complex enzyme system of the living cell.

The main conclusion emerging from the results described is that it is possible to analyse components of the respiratory system and to define the metabolic state of parts of the single intact mammalian cell.

This research has been supported by grants from the Swedish Medical Research Council, the National Science Foundation, and the Office of Naval Research.

[1] Thorell, B., and Åkerman, L., *Exp. Cell Research*, Supp., **4**, 83 (1957).
[2] Chance, B., Perry, R., Åkerman, L., and Thorell, B., *Rev. Sci. Instr.*, **30**, 735 (1959).
[3] Chance, B., and Williams, G. R., *J. Biol. Chem.*, **221**, 477 (1956).
[4] Thorell, B., "Adv. Biol. Med. Physics", **6**, 95 (1958).
[5] Thorell, B., and Chance, B., *Exp. Cell Research* (in the press).

CELL AND ORGAN CULTURE

TECHNIQUES of cell cultivation are being increasingly applied in all fields of biological research. Recent developments in these methods and in their application to cancer research were described by four speakers at a session of Section I (Physiology and Biochemistry) of the recent British Association meeting at York. Cell and organ culture techniques make possible the rapid proliferation of animal and human cells outside the body, and the maintenance *in vitro* of small organs or sections of organs in a healthy condition. It was appropriate that the chairman on this occasion was Dr. E. N. Willmer, one of the leading authorities on tissue culture techniques and research in the United Kingdom.

The first paper was concerned with recent technical advances in cell culture and was given by Dr. J. Paul (HERT Tissue Culture Laboratory, University of Glasgow). As Dr. Paul explained, tissue culture really began fifty years ago with Dr. Ross Harrison's demonstration that axons would grow out of nerve cells cultivated on frog lymph. Although the principles of the technique were at that time clearly stated, only a few biologists followed up this work with enthusiasm and success. One of the common objections to tissue culture in its first years was that the cells which grew were 'neither one thing nor another'. When tissues were explanted in a way which encouraged the rapid multiplication of cells, the organized pattern of the organ was destroyed and the cells which appeared could only be classified in most cases as either fibroblastic or epithelial. If the original morphology was retained, the cells developed abnormal features and deteriorated too rapidly for useful investigations to be undertaken. An outstanding achievement in the pioneer phase was the demonstration in Alexis Carrel's laboratory that avian cells could be induced to multiply indefinitely. This particular cell strain lasted for thirty years—several times the life-span of the fowl—and only died out when there was no one available to keep up the routine feeding and sub-culturing.

Dr. Paul described, with the aid of excellent diagrams, how the mechanization of the technique during the past ten years had led to its increasing use in research laboratories and in the pharmaceutical industry. Although the hard work of developing correct procedures had been done before 1949, the impetus for a rapid advance came from the demonstration by Enders and his colleagues that poliomyelitis virus would multiply in cultures of non-nervous origin. This was followed by the successful use of trypsin for producing suspensions of living cells from body tissues, a technical trick which made easier the large-scale cultivation of cells. Cultures of this type grow in an unorganized manner, and they may, as occasionally happens, produce permanent cell strains. Cells cultured from tumour tissue also grow indefinitely, and these permanent strains of different origin are available to any laboratory for investigations on their nutritional requirements and metabolism, and for virus and cancer research.

Such strains are, of course, specially adapted to grow in culture conditions and, genetically, they may form a most heterogeneous population. Another technical advance which opened the way to the study of the genetics of somatic cells was the discovery that single mammalian cells could be induced to multiply and form clones with distinctive features. This was first accomplished by Dr. Katherine Sanford at Bethesda, who developed an ingenious, although tedious, method of cultivating single cells within capillary tubes. Easier methods of cloning cells from permanent strains have since been devised, and the sublines are being used to study, for example, variations in the malignancy of cells and their response to irradiation.

The second paper in the session, by Dr. O. A. Trowell (Medical Research Council Radiobiological Unit, Harwell), was an entertaining account of the principles and practice of organ culture. The aim of this technique is to preserve the normal histology and functioning of the organ cells outside the body. Its success largely depends upon suppressing the outgrowth of cells, the principle originally demonstrated by Dr. Honor Fell in the cultivation of embryonic limb-buds. Dr. Trowell explained that the business of physiology is to find out how the animal body works and that the logical approach is to study the different organs one at a time. This can be done either by observing the behaviour of the organ in the intact animal in various states of bodily activity or by cutting the organ out of the body and studying its behaviour and capabilities under artificial but completely controlled conditions. These approaches are complementary, and his own choice was to study the isolated organ *in vitro*. The outcome of this approach depended upon keeping the tissue alive as long as possible, since there are many physiological and pathological responses of organs which take several days to develop. Dr. Trowell had, therefore, set out to study systematically the conditions which would maintain organ tissue in a healthy condition for a week or more.

The diffusion of oxygen and nutrients into all the cells of the organ culture can only be ensured by using tiny organs 2 mm. in diameter, such as pituitary, thyroid, adrenal, ovary and lymph nodes of rats and mice. With larger organs, it is necessary to cut off 2 mm. sections of tissue. Cultivation by immersion of the tissue in the medium proved unsuccessful because of the low solubility of oxygen, and efficient stirring of the medium only increased cellular damage. The oxygenation problem is solved by allowing the organ cultures to project into the gas phase. The tissues are, consequently, supported on a stainless steel grid, covered with fine tissue paper which is level with the surface of the medium. The grid, in its shallow dish, is kept in an atmosphere of oxygen at body temperature inside a sterile aluminium container. With this apparatus, many organs can be kept alive for as long as nine days; each 1 in. square grid can carry up to twenty cultures, and the medium can be sucked off and replaced without disturbing the tissues. Culture conditions are completely standardized by the use of a chemically defined medium.

Larger organ cultures would be an advantage, and Dr. Trowell hopes to achieve this by using tissue from horses and cows which have 'built into' their cells a much lower oxygen consumption and metabolism than is found in the cells from rats and mice. Cultures of cow tissue have shown that this is a feasible way of overcoming the limiting effect of oxygen diffusion. By adopting a 'mixed grill' technique, different organs, for example, endocrine organs and their target tissues, can be cultured in the same vessel, and their histology can be correlated with metabolic effects revealed by the changing composition of the medium.

The two remaining papers were concerned with the application of cell and organ culture in cancer research. Scientists and laymen who are still not convinced of the connexion between lung cancer and cigarette smoking ask for direct proof of the causal relationship. For the most sceptical, it is not sufficient to show, as has been done, that cigarette tar and the carcinogens it contains produce tumours in experimental animals; the only acceptable proof is that they induce malignancy in human lung cells. The organ culture technique used by Dr. Ilse Lasnitski (Strangeways Research Laboratory, Cambridge) provides the most direct experimental approach possible. Dr. Lasnitski described how she prepared lung cultures from human fœtal tissue and how the explants would, under normal conditions, show the characteristic formation of bronchioli *in vitro*. The normal histology of these lung cultures and the abnormal changes produced by 3,4-benzpyrene and three types of cigarette smoke condensate in the medium were beautifully illustrated by microphotographs of stained sections of the tissue. Two or three days of exposure to the carcinogen stimulated division of the epithelial cells, and in some sections taken from cultures about three weeks later cell proliferation had completely obliterated the lumen of the bronchioli. During the early stages the normal ciliary and secretory activity of the epithelium was intensified by the carcinogen, but later the cells lost the characteristic features of bronchial epithelium. Occasionally, cells with abnormal mitotic chromosomes were found in the treated cultures. Dr. Lasnitski made it clear that there is, as yet, no proof that cancerous cells had been produced in these experiments. The changes observed might be precancerous, but proof of malignancy would only be obtained if treated cultures would produce tumour-like growth after hetero-transplantation into experimental animals

The usefulness of organ culture was further illustrated by Dr Lasnitski's research on another form of cancer Malignancy of the prostate gland in men is one of the hazards of old age and it is of particular interest to the investigator that this type of cancer can temporarily be controlled by treatment with female sex hormones Cultures of mouse prostate gland were exposed to a chemical carcinogen, this time 20-methylcholanthrene, and again the epithelium of the alveoli became hyperplastic and produced a histology similar to that of skin Dividing cells with polyploid chromosomes were frequently seen in the cultures As in cases of human tumours, the cell proliferation was dependent upon the hormone, since the hyperplastic action of the carcinogen was abolished by the presence of œstrone in the medium and preserved by the male hormone, testosterone Dr Lasnitski concluded by describing briefly investigations on the metabolism of these cultures Autoradiographic studies, undertaken with Dr S R Pelc, showed that the carcinogen stimulated deoxyribonucleic acid synthesis in the epithelial cells, but inhibited deoxyribonucleic acid synthesis by fibroblasts after 2–8 days treatment Amino-acid uptake from the medium was investigated in collaboration with Dr J A Lucy and it was found that leucine and *iso*-leucine were well utilized by normal and treated cultures However, the uptake of arginine associated with normal cultures was decreased after a period of exposure to methylcholanthrene

In the fourth paper, Dr I Leslie (Department of Biochemistry, Queen's University, Belfast) described the search for metabolic features which distinguish normal and cancer cells, and the opportunities provided by cell culture for tackling this problem Three cell types are being studied in Belfast Normal cells are represented by short-term cultures of human fœtal tissues, and malignant cells by the *HEP* 1 strain, derived from a human carcinoma at the Sloan-Kettering Institute for Cancer Research, New York The *HLM* strain came from liver cell cultures prepared from a human fœtus in 1956 Unlike the other cells grown from this fœtus, the *HLM* cells grow indefinitely in culture and, in this respect, they resemble the *HEP* 1 carcinoma cells This 'transformation' of normal cells to an apparently 'immortal' form is not uncommon in cell culture and the process is open to investigation It is important to find how far transformed cells resemble cancer cells and how far they retain the properties of the parent cells The way in which these cells derive their energy from glucose was investigated in 1956 in collaboration with Drs W C Fulton and R Sinclair According to Warburg's original concept, the unique property of malignant cells is their ability to grow by means of the energy of fermentation, that is to say, the enzymic conversion of glucose to lactic acid During proliferation in cell cultures, however, the normal (fœtal) cells showed more intensive fermentation than the carcinoma or the transformed *HLM* cells Other investigators have reported similar results, and Warburg's recent studies on monolayer cultures of monkey kidney cells have caused him to change fundamentally his emphasis on fermentation as the essential feature of malignancy

The explanation of cancer has, therefore, to be sought elsewhere in the metabolism of the cell Since 1953, when Watson and Crick first described the deoxyribonucleic acid molecule and its process of replication, knowledge of cellular physiology has been progressing rapidly As a working basis, Dr Leslie suggested that cancer metabolism can be defined in terms of the biochemical events which lead to the continued replication of deoxyribonucleic acid and which are out of control of the normal restraints imposed by the adult organism It is necessary to study the metabolic events leading to deoxyribonucleic acid synthesis, and to find which are essentially different in normal and cancer cells

Four possible defects in cancer cells were discussed and illustrated by observations on cell cultures The defects were abnormal chromosomes producing modified cell proteins , the channelling of compounds into the synthesis of nucleic acids , the deletion of enzymes controlling the degradation of nucleic acids and proteins , and the loss of control over growth because of the altered response of cancer cells to hormones Evidence for enzyme deletion as a vital defect has come principally from biochemical investigations on liver tumours at the McArdle Memorial Laboratory, Madison, and the Montreal Cancer Institute Now, the absence of xanthine oxidase and arginase in both transformed and carcinoma cells is an example of this type of defect in permanent cell strains The failure of the *HEP* 1 cells of cervical origin to respond to œstradiol (although they respond to insulin) is possibly linked to the recent discoveries by American groups that œstradiol is the co-factor for a transhydrogenase system, and that this enzyme is much reduced in certain tumours It would, however, be wrong to suppose that there is one vital defect common to all tumours The encouraging features of current research are that the key problems in tumour metabolism can be clearly specified and that the techniques for solving them are available

I LESLIE

OBITUARY

Prof F. S. Bodenheimer

FREDERICK SIMON BODENHEIMER, who died in a London hospital on October 4 from internal complications after a successful eye operation, was born in Cologne on June 6, 1897, son of Max Bodenheimer, one of the founders of the Zionist movement As a schoolboy, he was attracted to biology, but was persuaded to study medicine, which offered a more certain future, at Frankfurt and Bonn His main interest was, however, still in zoology, and he obtained his Ph D at Bonn in 1921 with the intention of specializing in entomology and going to Palestine to work there He studied at the School of Agriculture in Geisenheim, and after spending half a year at Portici with Silvestri and Grandi, accepted an appointment as entomologist in the new agricultural research station of the Jewish Agency at Tel Aviv, where he worked during 1922–28

His studies during that period were concentrated on economic entomology, culminating in a book, "Die Schadlingsfauna Palastinas" (1930), but his interests were wider and his energy so inexhaustible that he succeeded, at the same time, in producing two volumes of the "Materialien zur Geschichte der Entomologie" (1928–29) and in carrying out an expedition to the Sinai with Dr. O. Theodor to settle the problem of the origin of manna, which proved to be the excretion of a coccid (*Najacoccus serpentinus*) on tamarisk. In 1928, he was appointed a Research Fellow, and in 1931 professor of zoology at the newly founded Hebrew University at Jerusalem. This opened a period of most fruitful research on a variety of biological problems, resulting in a long series of publications, the total of which during his life exceeded four hundred, including a number of books; apart from those already mentioned, he published "Animal Life in Palestine" (1935), "Prodromus Faunae Palaestinae" (1937), "Problems of Animal Ecology" (1938), "Animals in the Bible Lands" (1949, 1956), "Citrus Entomology in the Middle East" (1951), "Insects as Human Food" (1951), "The History of Biology" (1958), and "Animal Ecology To-day" (1958). His last book, just published, "A Biologist in Israel", is an extensive autobiography, and, at the same time, as he described it to me, "a history of a generation of ecologists".

Bodenheimer travelled extensively; in 1931, after a term as a visiting professor at Minneapolis, he went around the world, stopping where he would; during 1938–41 he was a visiting professor at Ankara and played a prominent part in developing entomological work in Turkey; in 1943 he was invited to Iraq to study the locust problem there; in 1955 he lectured in the University of Durham on Canon H. B. Tristram and visited Finland; in 1956 he went to Australia for a Unesco meeting on the Climatology of Arid Zones and took in South Africa *en route*. Wherever he went, he lost no opportunities of learning at first hand all that could be learned of local biological problems and institutions and workers.

His main life-interest was animal ecology in the broadest sense. His earlier published books on the subject did not receive sufficient recognition, since he had to write in English, which was not his own language, and many of his original ideas have been offered in a not easily digestible form. Moreover, he was never easily satisfied with formal definitions of concepts and always searched for other than the accepted solutions of such basic problems as the equilibrium in animal populations, animal communities, the interaction of environment and heredity, etc. On many of these points he was outspokenly critical of views of others, but his criticisms were always such as not to annoy, but to stimulate.

As an entomologist, Bodenheimer left a great heritage, but he was also well known to mammalogists for his studies on the vole (*Microtus*) populations in Palestine, and before his death he prepared a revision of Canon Tristram's work on the mammals of Palestine.

His many travels and his deep interest in the work of others have made Bodenheimer well known to a large number of biologists all over the world and his early death will be deeply regretted by many. His wife, Mrs. Rachel Bodenheimer, who accompanied him on many of his travels, made friends wherever she went. Their many friends will share her feeling of loss.

B. P. Uvarov

NEWS and VIEWS

Chief Scientist of the Ministry of Supply: Dr. R. Cockburn, C.B., O.B.E.

On October 1, Dr. Robert Cockburn took up the post of chief scientist of the Ministry of Supply. Cockburn gained his first degree at the University of London when he was only nineteen, adding to it later both the M.Sc. and the Ph.D. From 1930 he taught science at the West Ham Municipal College, and at the same time conducted research on the effects of electron transit time in very high-frequency oscillators, until, in 1937, he joined the Radio Department of the Royal Aircraft Establishment, Farnborough, where he was engaged in the development of a new very high-frequency communication system for the Royal Air Force. From 1939 until 1945 Cockburn was at the Telecommunications Research Establishment, Malvern, where he and his team developed and used radio counter-measures of all kinds in the protection both of targets in Britain and British bombers operating over enemy territory. For his outstanding work he was appointed O.B.E. in 1946. He spent a short period at Chalk River and at Harwell, until in 1948 he became scientific adviser to the Air Ministry. He stayed there for five years, joining the Ministry of Supply in 1953, where he has been successively responsible for research and forward thinking in all applications of electronics, for the organization of all the research and development programmes in this field, and since 1956, as controller of guided weapons and electronics, for the whole field of research, development and production of these equipments.

Cockburn brings to his new post exceptional practical knowledge of the operational use and technical requirements of systems that he gained in the Second World War, the intimate knowledge of the Services that he acquired when at the Air Ministry, and the inside knowledge of the Ministry of Supply gathered in the three senior appointments that he has already held there. He adds these to his wide basic scientific knowledge and his international standing and prestige as a scientist who has concentrated on the special problems of defence. His appointment is warmly welcomed by his professional colleagues, Service and scientific, throughout the many circles in which he is well known.

Engineering at Leicester: Prof. E. W. Parkes

Dr. E. W. Parkes has been appointed to the new chair of engineering in the University of Leicester. Dr. Parkes was born at Sutton Coldfield in 1926, and was educated at King Edward's School and St. John's College, Cambridge, where he gained first-class honours in the mechanical sciences tripos in 1945. After leaving Cambridge, he worked for a year at the Royal Aircraft Establishment and for two years with the Hawker Siddeley group on the design and testing of aircraft structures. He returned to

Cambridge in 1948 to study the elastic stresses in flanged beams. In 1950 he was appointed University demonstrator and afterwards lecturer. He was elected into a fellowship at Gonville and Caius College in 1954, and in 1957 was appointed tutor. Dr. Parkes's main fields of research are the inelastic dynamic behaviour of structures and the behaviour of structures subjected to temperature variation. He is particularly interested in repeated thermal loading phenomena such as incremental collapse under thermal cycling. In the industrial field, Dr. Parkes has acted as consultant on the design of crane jibs, tall towers, bridges, boilers and vacuum vessels. He has lectured on his work on thermal stresses on a number of occasions in Denmark and Sweden and is at present spending six months as visiting professor at Stanford University, California, working in the same field.

Highway and Traffic Engineering at Birmingham

Prof. J. Kolbuszewski

DR. J. KOLBUSZEWSKI, who has been appointed to the chair of highway and traffic engineering which has recently been established within the Department of Civil Engineering at the University of Birmingham, joined the University as a lecturer in 1951, the title of reader in soil mechanics being conferred on him in 1957. During the past three years he has been in charge of the Graduate School of Highway Engineering and the Graduate School of Foundation Engineering. Originally, Dr. Kolbuszewski graduated from the University of Lwow, where he was afterwards a lecturer in civil engineering. He served throughout the Second World War with the Polish, French and British armies. After the War he studied at the Imperial College, London, where he obtained his Ph.D. degree. He was a member of the staff of the Polish University College, London, from 1946 to 1950, joining as a lecturer and being promoted to professor and director of studies in 1947.

Dr. Kolbuszewski's research interests have been principally concerned with problems in soil mechanics and foundation engineering, and, in particular, with problems arising in connexion with pressures under pavements and the trafficability of beaches. A few years ago he carried out some original experiments in the Sahara Desert, when he obtained some interesting information regarding the bearing capacity of wind-deposited sands.

Radiation Protection

THE occupational hazards associated with radioactive materials have for a generation been under periodic review by the International Commission on Radiological Protection, which is a commission set up by the International Congress of Radiology and by national bodies. In the United States this is the National Committee on Radiation Protection, which issued its latest report on June 5 (U.S. Department of Commerce: National Bureau of Standards Handbook 69: Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure. Pp. viii+95. Washington, D.C.: Government Printing Office, 1959. 35 cents). The chairman of the sub-committee responsible for this report is also chairman of the corresponding international committee. It can therefore be taken that this document is in many respects a pre-view and abbreviated version of the corresponding recommendations of the International Commission on Radiological Protection which are now in press.

Previous figures for permissible body burdens of radioactive nuclides were given in 1953. The basis for recommendations concerning permissible exposure was revised recently (Recommendations of the International Commission on Radiological Protection, September 9, 1958. Pergamon Press, London, 1959). This has led to corresponding revision to smaller permissible body burdens only for nuclides which result in irradiation to the whole body. However, new biological data and improved methods of calculating physical doses have led to a complete re-assessment of values. This has allowed permissible figures for some nuclides to be increased; notably twice as much strontium-90 as before is now allowed. At the time this produced a furore in the American daily press. On strictly logical grounds the committee could have raised the value five-fold. That it did not do so indicates that judgment and opinion as well as numbers have been used rather than strict logic. After all, the figures are not magical; they are still capable of revision in the light of further information and experience after a further quinquennium.

International Council of Scientific Unions

THE financial statement of the International Council of Scientific Unions for the period November 1, 1957, to December 31, 1958 (pp. 12. The Hague: International Council of Scientific Unions, 1959), records an excess of expenditure over income for the period of 16,638 dollars, in spite of a further increase in the income from member unions to 2,852 dollars. The 67,428 dollars received from national members during the year includes 20,898 dollars, representing annual dues previously in arrear. The increase in expenditure from 42,970 dollars in 1956–57 to 88,139 dollars is attributed to the increasing scientific activity of the Council, the higher costs of running the Secretariat, mainly due to increased staff, the heavy costs of holding the 1958 General Assembly and Meeting of the Executive Board in the United States and the establishment of a Secretariat in The Hague, apart from the fact that running expenses are for fourteen months instead of the normal twelve. For the triennium 1959–61 the eighth General Assembly adopted a budget of 58,000 dollars per annum, and the Assembly also strongly endorsed the decision of the Executive Board to establish a capital fund.

University Foundation of Belgium

DURING the academic year 1957–58 the University Foundation of Belgium distributed subsidies totalling 4,858,992 francs and 2,441,500 francs in awards for ordinary studies. Of the latter, 1,046,500 francs were at the University of Louvain, 718,000 francs at the University of Ghent, 359,000 francs at the University of Brussels and 198,500 at the University of Liège. Of the 167 awards, 32 were in science, 4 in pharmacy, 33 in medicine, 1 in veterinary medicine, 3 in dental science, 32 in engineering, 4 in agronomy, 5 in political, social or administrative science, 5 in commercial or economic science or finance, and 4 in applied psychology and vocational guidance. Five awards were made for courses of study abroad: four in France and one in Switzerland. Subsidies for the publication of scientific works amounted to 458,500 francs and to periodicals to 2,158,000 francs, while scientific associations received subsidies amounting to 606,000 francs The thirty-eighth annual report of the Foundation (Fondation Universitaire Trente-huitième Rapport Annuel, 1957–1958 Pp 148 Bruxelles Fondation Universitaire, 1959) which gives these figures, includes a list of beneficiaries during the year, as well as some notes on institutions with which the Foundation has connexions It also includes a list of bursars for 1958–59 under the Belgian American Education Foundation, Inc , both in Belgium and in America Of the 29,651 university students enrolled in 1957–58, 81 5 per cent were men and 18 5 per cent women 11 35 per cent were in science, 25 33 per cent in medicine and pharmacy, 11 62 per cent in applied science, 2 52 per cent in agronomy, 6 15 per cent in social, political and economic science, and 13 16 per cent in commercial science Of 4,770 diplomas obtained in 1956–57, 630 were in science, 1,035 in medicine and pharmacy, 33 in veterinary medicine, 405 in applied science, 151 in agronomy, 266 in social, political and economic science, and 654 in commercial science

Industrial Psychology Grant Increased

The Department of Scientific and Industrial Research is to continue its annual grant to the National Institute of Industrial Psychology for a further five years The amount is to be raised from £4,000 to £6,000 a year, on the understanding that the Institute will increase to £9,000 a year its own income from membership subscriptions and special contributions for long-term research The Department of Scientific and Industrial Research is also to add another £100 a year for every £100 of grant-earning income which the Institute can obtain in excess of the qualifying £9,000, up to a maximum of another £6,000 a year This means that if the Institute can raise £15,000 a year from industry, the Government will give it £12,000 The grant and the grant-earning income have to be put in a special fund and used only for long-term research. Among research projects now in train are an inquiry into workers' attitudes to the opportunities and rewards offered by their jobs which may have a bearing on personnel policies ; an investigation into the relation between satisfaction and efficiency on the job , a study of industrial management structure and efficiency , and experiments on tests for manual skill The Institute has received many inquiries from industry recently about the special tests it has devised for selecting suitable school-leavers to be engineering apprentices

Australian Atomic Energy Commission Research Grants

Research grants totalling almost £28,000 have recently been awarded by the Australian Atomic Energy Commission in support of research under contract in seven Australian universities Fields covered include chemistry, physics, geology, mining, electrical, metallurgical and chemical engineering, and the biological sciences The grants have been made for work in fields which will contribute to the Commission's own work in developing civilian uses of atomic energy

Alkali and Similar Works in Britain

The ninety-fifth report of the Chief Inspector on Alkali, etc , Works in England and Wales covering the year 1958 notes an increase in the number of works registered under the Act from 872 at the end of 1957 to 2,160 at the end of 1958 It also shows an increase in the number of separate processes from 1,733 to 3,412 in consequence of the extensions of the list of scheduled works and of noxious or offensive gases under the Alkali, etc , Works Order, 1958 Many of the new registrations relate to very large undertakings, particularly as regards the iron and steel industry and the newer electric power stations The result of these increases is that the staff of the inspectorate has been increased, and it will now be necessary to adjust the internal organization The 7,142 visits and inspections during the year included 255 special visits by the chief and deputy chief inspectors and 32 by Mr W A Damon, the former chief inspector, who continues to serve in a special advisory capacity Several visits were again paid to establishments of the Atomic Energy Authority, and discussions with the Authority during 1958 covered problems arising out of the nuclear power problem, particularly as regards the increased scale of processing uranium for use as a fuel and of irradiated uranium from the projected nuclear power installations Considerable interest has been shown by local authorities in clean air matters and in the processes scheduled by the 1958 Order, and friendly and adequate liaison and co-operation appear to have been established There were twelve infractions of pre-1958 processes compared with seventeen in 1958, and of these, six related to escapes of acid gases in excess of statutory limits and six to failure to use 'best practicable means' The Chief Inspector for Scotland reports 213 visits during the year, including 27 in connexion with the Alkali, etc , Works (Scotland) Order, 1958, mainly about points of doubt in applications to register In the course of 89 chemical tests, three infringements were found, two in chamber sulphuric acid plants, which appeared to be quite inadvertent, and one at a plant for concentrating sulphuric acid Two further infringements were noted during visual inspection of premises registered for distillation of tar

New Journal of Psychopharmacology

Literature on psychopharmacology has hitherto either appeared as contributions to symposia, of which the past years have seen ever-increasing numbers, or been scattered in the periodicals of many disciplines, such as psychology, psychiatry, physiology, biochemistry and pharmacology *Psychopharmacologia* is a new journal aiming at finding a single home for the investigations on the effect of drugs on behaviour carried out by workers with the greatest variety of training (Vol 1, Fasc 1 Pp 78+10 9 60 D M Maximal-preis 1959, 40 D M Maximal-preis 1960, 80 D M Berlin Springer-Verlag, 1959) There will be some overlap with the recently launched periodical *Biochemical Pharmacology* as there will be with the *Journal of Neurochemistry*, but interest in this field has been so great in recent years that the editors will experience little difficulty in obtaining manuscripts of the highest standard Papers will be accepted in English, French or German The advisory board is recruited from Western Europe and North America The first number contains a review and a number of original articles and makes interesting reading It is to be hoped that psychopharmacologists, while keeping up with their own discipline, will find time to read yet another integrating journal

Bird Paintings of the Eighteenth Century

The Trustees of the British Museum have published an account of "Some Eighteenth Century Bird Paintings in the Library of Sir Joseph Banks (1743–1820)", by Averil Lysaght (*Bull. Brit. Mus. (Nat. Hist.)*, Historical Series, 1, No. 6. Pp. 251–371+plates 35–37. From the Museum. 40*s*.) This collection, ultimately passing to the British Museum, included the work of various artists accompanying Captain Cook on his three voyages. These are of interest to systematists in that some of the drawings rank as the types of the then newly discovered species, the actual specimens having deteriorated or perished. The record is of all the more value in that some of the species have meanwhile become greatly reduced in numbers and geographical incidence, if not extinct. Owing to the accident that some of the illustrations remained in Bloomsbury when others were transferred to South Kensington in 1880, these were overlooked by Bowdler Sharpe and others. The task of making a new assessment was originally suggested by the late Sir Norman Kinnear.

Microcard Adapter for 'Dagmar' Microfilm Reader

The Dutch 'Dagmar' microfilm-microfiche reader, which was introduced into Great Britain in 1957, has proved itself to be a good, cheap, portable reader with many attractive features. It has been made even more versatile by the addition of a microcard adapter. This has been developed in the library of the Manchester College of Science and Technology and it is now being manufactured for sale to others. Anyone already owning a 'Dagmar' can effect the alteration necessary to take the adapter in a few moments. A small hole has to be cut in the front panel above the lens and a triangular casting bolted on. This takes the condenser system of the adapter and positions the illumination so that it shines down on to the microcard which is in the glass microfiche holder. The adapter is being distributed by Trew Microfilming, Ltd., 22 Park Lane, Croydon, at about £19.

Museum of Applied Science, Victoria

Those engaged in museum work have often deplored the name but have failed to find an adequate substitute. The Report of the Museum of Applied Science for the year ended June 1958 states that the Trustees have unanimously recommended that the term 'Institute' shall replace 'Museum', and they trust that the necessary legislation to effect the change shall be introduced. It is felt that the new title will indicate more clearly the present functions and activities, especially as the displays interpret the rapid and continuing advances in applied science and technology. The International Geophysical Year was well publicized both by means of special displays and booklets.

Cancer Current Literature Index

The Excerpta Medica Foundation, which has its main office in Amsterdam, provides a monthly comprehensive series of abstracts on branches of medicine, one of which is devoted to cancer. The August issue of the cancer section is a sizeable volume of 170 pages containing nearly 600 abstracts. The Foundation has now, in collaboration with the U.S. Cancer Society, begun the production of a still more condensed form of abstracts which consists only of title, author and reference to publication; the first number (September) is a guide to 300 papers, dealing with different aspects of cancer research. The aim of this publication, which has been made possible by a grant from the U.S. Cancer Society, Inc., New York, is to provide a regular, up-to-date index of the bibliographical references to the world's literature in the field of cancer. The "Cancer Current Literature Index" will appear at intervals of two to three weeks. Each yearly volume will contain approximately 4,500 references from some 3,000 medical journals published all over the world, including those from the U.S.S.R.

Cattle and Buffaloes of India

About 20 per cent of the total number of cattle in the world exist in India, and while at present they are mainly used for draught purposes, their potentiality, at present but poorly developed, for milk supply is great. Improvement of these cattle for milk production would not only supply one of the main nutritional needs of the Indian peoples but also would improve the economic position of the peasant farmer by giving him the weekly income which he does not receive from crop farming alone. One of the steps towards an improvement is the holding of cattle shows for the development of special breeds. A bulletin published by the Indian Council of Agricultural Research on "Bovine Stars of India" illustrates some of the best individual cattle of different breeds exhibited at four Regional and the All India Cattle Shows in 1955 (Indian Council of Agricultural Research Misc. Bulletin No. 82. Pp. iv+29. Delhi: Manager of Publications, 1957. Rs. 2.37, 4*s*.) It is stated that some of the cattle have been given prizes for being the best milch type, but the absence of any actual records of production to go with the photographs is to be regretted. Since the buffaloes and native Zebu breeds of cattle have a high degree of heat tolerance it is on their improvement rather than by the introduction of European breeds, lacking heat tolerance, that the future milk supply of India lies. Bulls and cows of some twenty-six breeds of cattle and three breeds of buffaloes have been photographed against a squared background which enables one to judge actual size, and an attempt is to be made to record body measurements at future shows. Some good draught type cattle are also illustrated, but one wonders how long it will be before they are replaced by mechanization.

Pest Control

The Ministry of Agriculture, Fisheries and Food has published under the title "Infestation Control: a Service to Agriculture and Food Storage" (pp. iv+32+12 plates. London: H.M. Stationery Office. 4*s*.) a pamphlet describing the research carried out by its officers on the problems of infestation control in farms and warehouses, together with a brief history of the subject in Great Britain. The work falls into two main parts, one dealing with the insect pests of stored foodstuffs, the other with vertebrate enemies, such as rodents and birds. By what must be regarded as a political accident, vertebrates are covered whether they attack crops in the field or in store, whereas the invertebrate field pests are the responsibility of another section of the Ministry. Both parts of the pamphlet cover a surprisingly wide range of topics in which the application of scientific method has made important contributions to public health or profit. These concern especially the control of insect pests by chemical means and the development of new techniques for baiting rodents and, more recently, the development of anti-coagulant poisons. Perhaps characteristically in Britain, the pioneer work was done in the universities and received final Government blessing during the Second World War. There is a useful list of papers published by members of the infestation control division during the past fifteen years.

Nitrogen Replenishment in the Soil

LAND fertility improvement was the theme of the presidential address by Dr. N. R. Dhar, of the University of Allahabad, this year to the Indian Society of Soil Science held at Delhi. He points out that the amount of fertilizer used in the world is still very inadequate and production of nitrogen fertilizer appears to be lagging behind production of phosphate and potash. Under-developed countries are poorly equipped with nitrogen-fixation factories because of the high capital investment involved. Dhar estimates that approximately one hundred million tons of fixed nitrogen is necessary for the food supply of the world, but present production is less than eight million tons. This emphasizes the importance of other nitrogen sources. For example, legumes probably fix five million tons of nitrogen and rain contains about ten million tons. It is also pointed out that the amount of nitrogen lost in refuse from urban areas is about equivalent to the amount of nitrogen supplied to world crops as fertilizer. Even in highly organized agriculture such as in the United States, more nitrogen is removed from the soil than returned as fertilizer, resulting in an annual deficit of six million tons. This translated into world figures means a loss of about fifty million tons of nitrogen a year. This annual loss must be compensated in permanent agriculture by natural methods of recuperation. By making assumptions concerning the amount of carbon added to the earth by photosynthesis and the proportion of this which in turn is oxidized, it is estimated that one hundred and ten million tons of nitrogen a year is fixed by natural processes. Hence this is the chief natural source of soil nitrogen and far exceeds the amount supplied by fertilizers.

Tectonics in the U.S.S.R.

A GREAT advance in tectonics was made by the publication of the tectonic map of the Soviet Union in 1957 on the scale of 1:5,000,000, published on nine sheets. This map is coloured vividly in accordance with the orogenic age of the formations, with tints and shadings indicating various folding phases and structural features. The map was compiled by a number of geologists under the direction of N. S. Shatsky, one of the foremost tectonists in the Soviet Union. It was accompanied by an explanatory memoir written by N. S. Shatsky and A. A. Bogdanov. A small-sized variant of this map is published by Y. A. Kosygin (*Priroda*, 8, 21; 1958) as an illustration for his article dealing with new methods applied to the study of tectonic structure of the Earth's crust by means of deep stratigraphical boreholes. This method, according to the author, is particularly suitable for the study of the 'cover' of ancient 'platforms' and also for the preparation of 'palæogeological' maps of the 'floor' of the 'cover'. In another article Y. A. Meshcheryakov (*Priroda*, 9, 15; 1958) discusses 'neotectonics'—a term proposed by V. A. Obruchev for the study of the recent or near-recent movements of the Earth's crust. In this article he gives a 'neotectonic' map of the European part of the Soviet Union and a generalized map of the world showing regions of recent elevation and depression as well as the earthquakes zones. This map shows that the modern regions of elevation are not confined to the areas of Quaternary glaciation and therefore cannot be explained by the hypothesis of glacial isostasy control.

Meteorological Data

RADAR is a powerful tool for the meteorologist in the detection of precipitation as it is the only means of locating the positions of all precipitation falling at above a certain moderate rate and at any one time within a distance of the order of 100 miles from the transmitter. The strength of the radar echo is proportional to ND^6/L^4, where N is the number of drops in unit volume, D the drop diameter and L the wave-length of the radar. The echo intensity thus increases very rapidly with the size of the drops. The advantage of a very short wave-length is, however, offset by increased attenuation of the beam by precipitation and the water vapour and oxygen of the air, and by engineering difficulties of obtaining adequate radiant power. In practice, wave-lengths in the region of 3–10 cm. are mostly used, giving admirable representation of moderate and heavy rain at distances up to 100 miles or more. Radar is of great value for guiding aircraft in and out of airfields to avoid highly turbulent thunderclouds, in forecasting the approach to cities of thunderstorms with their effects on public transport and demand for lighting, and also in the study of cloud structure and hydrology. The subject is comprehensively discussed in all its aspects in a recent report by the World Meteorological Organization prepared by a Working Group of the Commission for Instruments and Methods of Observation under the chairmanship of Mr. R. F. Jones, of the Meteorological Office (Technical Note No. 27: Use of Ground-Based Radar in Meteorology (Excluding Upper-Wind Measurements). Pp. xvi+80. Geneva: Secretariat of the World Meteorological Organization, 1959. 9 Swiss francs.) This describes the basic theory, types of radar and display, recording and transmitting the information, the types of radar echo associated with clouds and precipitation, echoes from other phenomena such as smoke, insects and birds, the practical applications and the use of radar in research.

European Nuclear Energy Project, *Dragon*

THREE engineers, one from Switzerland and two from Italy, arrived in Britain on September 21, representing the advance guard of some ninety European engineers and scientists who, with 160 from the United Kingdom, will comprise the international staff of the *Dragon* project of the Organization for European Economic Co-operation at the Atomic Energy Establishment, Winfrith, Dorset (see *Nature*, 183, 507; 1959).

Harwell Reactor School Courses

STANDARD Course No. 20 of the Harwell Reactor School will commence on January 4 and continue until April 29, 1960. These courses, which began in September 1954, are designed to train engineers in the techniques of reactor construction and operation, particularly in connexion with nuclear power stations A special course for senior technical executives, the tenth of its kind, will be held during May 9–20, 1960 Application forms and details of both courses can be obtained from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berks

University News : Oxford

It is announced that the Medical Research Council has provided a grant not exceeding £1,100 for the year beginning October 1 for scientific assistance in a study of X-ray analytical methods of insulin and related structures, to be carried out in the Laboratory of Chemical Crystallography under the direction of Dr D M Hodgkin A grant not exceeding £5,700 for the three years beginning October 1 has been provided by the United Kingdom Atomic Energy Authority for studies in interferometric spectroscopy to be carried out in the Clarendon Laboratory under the direction of Dr H G Kuhn, and in addition a further grant not exceeding £1,250 during the period October 1, 1959, to September 30, 1960, for work on the constitution of bismuth-rich alloys being carried out in the Department of Metallurgy under the direction of Prof W Hume-Rothery

The United States Public Health Service has provided a sum of 14,160 dollars for the year which commenced September 1 for the continuation of research on vision and light quanta, being carried out in the Department of Physiology by Dr M H Pirenne, under the direction of Prof E G T Liddell

Grants are to be received from the Department of Scientific and Industrial Research as follows £1,000 for the year beginning October 1, for research on some natural products with biological activity, to be carried out in the Sir William Dunn School of Pathology under the direction of Dr E P Abraham, £1,500 for one year as from October 1, for research into perceptual limitations in high-speed performance, to be carried out in the Institute of Experimental Psychology by Dr H Kay, under the direction of Prof R C Oldfield, £22,860 for the three years ending September 30, 1962, for an investigation of the geological age of rock series by methods based on natural radioactivity, being carried out in the Department of Geology under the direction of Prof L R Wager, £1,220 for equipment for research on the biochemical mechanism of cell division, to be carried out in the Department of Biochemistry under the direction of Sir Hans Krebs, £25,725 for the period October 1, 1959, to July 31, 1962, for an investigation of materials, using magnetic resonance and double resonance techniques, to be carried out in the Clarendon Laboratory under the direction of Prof B Bleaney, £17,610 for the period October 1, 1959, to July 31, 1962, for an investigation of nuclear orientation and nuclear cooling in magnetic fields to be carried out in the Clarendon Laboratory by N Kurti under the direction of Prof B Bleaney The Ministry of Supply has provided a grant not exceeding £1,175 for the year as from September 1, 1959, for the continuation of an investigation of fluorocarbohydrates being carried out in the Department of Biochemistry under the direction of Dr P W Kent £2,200 is to be expended from the University General Fund on alterations to the Department of Zoology in order to provide additional teaching space

Mr F A Burchardt, director of the Institute of Statistics, who died on December 21, 1958, has been succeeded by E F Jackson, Fellow of St Antony's College

World Meeting on Veterinary Education

A world meeting on veterinary education, to be held in London during April 25–29, 1960, is being convened by the Food and Agriculture Organization The meeting will be held at Church House, Westminster, by invitation of H M Government, and will be attended by participants from most parts of the world, including the Far East, Latin America, the Near East and Africa

British Society of Rheology

The British Society of Rheology has announced the following officers for the year 1959–60 *President*, Dr H Kolsky (Armament Design Establishment), *Hon Secretary*, Dr M F Culpin, *Hon Treasurer*, Mr C C Mill, *Hon Editor* (*Bulletin*), Mr J F Hutton (Shell Research, Ltd), and *Hon Editor* (*Abstracts*), Dr J C Vernon

British Electronic Achievements

The scheme for awarding annual premiums for articles on electronics, organized in the past by the Radio Industry Council (London) is now under the joint sponsorship of the Council and of the Electronic Engineering Association Articles published during 1959 will be considered by the panel of judges early in the New Year, and explanatory leaflets can be obtained from the Electronic Engineering Association, 11 Green Street, London, W 1, to which also eligible articles should be submitted before the end of the year

The Annual Review of Pharmacology

Annual Reviews, Inc, of Palo Alto, California, announces the organization of a new series "The Annual Review of Pharmacology". The first volume is scheduled to appear in April 1961 Prof Windsor C Cutting, of Stanford University, has been appointed as editor, and Prof Henry W Elliott, of the University of California, as associate editor Members of the Editorial Committee, under whose direction the Reviews will be organized, are initially as follows Windsor C Cutting (*chairman*), Bernard B Brodie, National Heart Institute, Maynard B Chenoweth, Dow Chemical Co, Louis S Goodman, University of Utah, G B Koelle, University of Pennsylvania, Chauncy D Leake, Ohio State University, and Maurice H Seevers, University of Michigan

Announcements

Mr A Perera, representing Ceylon, has been appointed chairman of the Executive Council of the Commonwealth Agricultural Bureaux, in succession to Dr J G Malloch Mr C K Reheem, representing Pakistan, has succeeded Mr Perera as vice-chairman

Erratum In the communication entitled "Production of Serum Albumin and of Globulins ", by Prof E Broda *et al*, in *Nature* of August 1, p 361, the penultimate line of column 1 should be at the foot of column 2, further, Dr Leslie's strain referred to in column 2 should be *HLM* and not *HIM* as printed

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

PRESENT STATUS

THE European Organization for Nuclear Research (CERN) has in operation a synchrocyclotron, accelerating protons to 600 MeV., and is in course of constructing an alternating-gradient synchrotron which is designed to accelerate protons up to 25 GeV. In addition to these two accelerators, CERN is building up on its site at Meyrin, near Geneva, experimental equipment and services comparable with those existing or being built at Brookhaven and Berkeley in the United States and at Dubna in the U.S.S.R.

The synchrocyclotron, which has been running for more than a year and in recent months has operated for 95 per cent of the scheduled time, is yielding an ever-increasing flow of experimental results. Analysed beams of mesons, neutrons and protons are available in two experimental halls on either side of the machine. The most recent experiments which have been completed include a charge-independence experiment concerning the ratio of the cross-sections of the reactions $p + d \rightarrow H^3 + \pi^+$ and $p + d \rightarrow He^3 + \pi^0$, which should be (apart from Coulomb and mass correction) exactly 2. The experimental accuracy achieved was 5 per cent, which is perhaps the most precise confirmation of charge-independence yet obtained at high energies. An experiment in an earlier stage is examining the neutron groups from the reactions $\pi^- + p \rightarrow \pi^0 + n$ and $\pi^- + p \rightarrow \gamma + n$ with 70 MeV. pions. This has already yielded an accurate value of the π^0 mass. Two experiments which are now being designed are on the scattering of μ-mesons by nuclei (for which a focusing channel for muons is under construction) and an experiment for the accurate measurement of the anomalous part of the magnetic moment of the muon. Two experiments using hydrogen bubble chambers are just starting; the first, using a 25 cm. diameter chamber brought to CERN by an Italian group, deals with the scattering of 350 MeV. pions by protons, and the second, using a 30 cm. diameter chamber built at CERN, deals with the double production of π-mesons. Many other experiments are being carried out with the synchrocyclotron by teams of CERN physicists and by visiting groups from the member countries of CERN. About 30 per cent of the running time of the machine is scheduled for these visiting groups, which include teams from Padua, Utrecht, Harwell and University College, London.

The magnet units of the 25 GeV. proton synchrotron, one hundred in number and weighing in total 4,000 tons, are mounted in the machine building, a subterranean annular tunnel covered with 3 m. of earth. Pulsing tests on the magnet, using the rectifier-inverter set and generator, began in the latter part of July. The vacuum system, a 620 m. long elliptic tube pumped by fifty vacuum pumping stations, is nearly assembled, as are the sixteen radio-frequency accelerating stations. Two tanks of the three-tank linear accelerator, which will inject protons with an energy of 50 MeV. into the synchrotron, are working, giving 3.5 m.amp. of 30 MeV. protons.

Considerable thought has gone into the planning of the experimental apparatus to be used with the 25 GeV. accelerator and into the layout of this apparatus in the experimental halls. The largest pieces of equipment being built at CERN are a 2 m. long liquid hydrogen bubble chamber, a 1 m. diameter propane bubble chamber and a 2 m. long gas Čerenkov counter. The propane chamber, complete with its magnet, giving a field in the chamber of 18,000 gauss, weighs about 100 tons and is planned to come into operation in the middle of next year. The hydrogen chamber and its magnet weigh about 600 tons and are scheduled for operation in 1962. A French group from the Centre d'Études Nucléaires, Saclay, will bring an 80 cm. long hydrogen bubble chamber to CERN towards the end of 1960, and a British group plan to bring an even larger hydrogen chamber in 1961. Another French group, from the École Polytechnique, Paris, plans to bring a 1 m. long propane bubble chamber next year. These 'visiting' bubble chambers will be used at CERN by mixed teams of CERN physicists and the physicists coming with the chambers. Initially, the 30 cm. diameter CERN hydrogen bubble chamber will be used for exploratory experiments. To get momentum-analysed and purified beams of particles to these bubble chambers and to counter experiments, systems of bending and focusing magnets have been designed and ordered, and a 30 m. long beam separator is in course of study. Direct current generators, totalling 8 MW. capacity, are being installed to power these experimental magnets.

Although about 500 sq. m. of floor area are at present available for experiments with the proton synchrotron, this space will be fully occupied by experimental equipment within a year or so of the accelerator coming into operation. A new experimental area, foreseen for use in 1962, will provide special buildings for the very large hydrogen bubble chambers and a 600 m. long flight path for the beams of particles emerging from the synchrotron. This long flight path is necessitated by the extreme difficulties encountered in trying to distinguish between different types of particles at such high energies where all particles, irrespective of their rest mass, are travelling at very nearly the velocity of light. It is possible to discriminate between different particles only after they have travelled hundreds of metres, when the small relative velocity differences of the particles have resulted in a time separation which can be measured by electronic discriminators with resolution times of a few nanoseconds (10^{-9} sec.).

The analysis of the bubble chamber photographs will be carried out with semi-automatic measuring machines, designed at CERN, similar to those already in use at the Radiation Laboratory at Berkeley. The output of these machines, in digital form, is fed into the Ferranti *Mercury* computer now in operation at CERN, for spatial reconstruction and kinematic analysis of events.

In addition to the experimental groups using the 600 MeV. synchrocyclotron and planning experiments with the 25 GeV. synchrotron, there is a strong theoretical group established at CERN which not only contributes to pure theory, but also takes an important part in the initial planning of experiments and in the interpretation of the experimental results. Among the problems studied by this group are those of parity conservation in strong and weak interactions, particularly how it is possible to reconcile the violation of parity in strong interactions involving K-mesons with the quasi conservation in nuclear interactions involving π-mesons Another problem being studied relates to the magnetic moment of the μ-meson

Apart from the two accelerators, their experimental programmes and theoretical work, CERN is carrying out a basic research programme on new methods of accelerating particles, the results of which can be used as a basis for future machines and to improve the existing machines The Accelerator Research Group is at present studying intersecting-beam machines that will yield energies in the centre of mass system higher than is practicable with existing machines using targets in which the bombarded nuclei are at rest, very high current machines using beam stacking techniques, and plasma accelerators that can either be used as high-current machines or to provide, by means of very high circulating electron beam currents, intense magnetic guide fields for heavier particles Several experimental plasma betatrons have been built, and an electron beam stacking model is now being planned which will provide a flexible experimental tool for investigating stability problems in high-current beams and in intersecting-beam machines

The total staff of CERN is nearly a thousand, about two hundred of which are physicists and engineers, and in addition to staff appointments CERN offers fellowships to enable physicists from all over the world to participate in the work of the Laboratory About sixty physicists are currently using these fellowships at CERN

THE BRITISH COMPUTER SOCIETY

FIRST CONFERENCE

IN view of the widespread interest in computers nowadays, particularly in the fields of science and engineering, it is perhaps, a little surprising that the British Computer Society should have held only its first conference last June However, as the president, Dr M V Wilkes, reminded us, it was not the first time that a conference of those interested in computing had been held at Cambridge, the last one being almost exactly 10 years previously, when the subject was in its infancy The rapid growth of interest in the subject is instanced by the capacity attendance of 330 at the conference and by the increasing membership of the British Computer Society, which is now more than 2,000, drawn from a wide variety of backgrounds

These differing backgrounds accounted for the considerable range of topics discussed, running from the structure of myoglobin through automatic programming and logical design to the problems of auditing accounts kept by computers The work currently being done by Perutz, Kendrew and others on protein structures would scarcely have been possible without the use of fast computing machinery, and Dr J C Kendrew, in his interesting address, brought out clearly the importance of the existence of, and of further developments in, these powerful tools He described the work recently done on the structure of myoglobin, mainly using X-ray diffraction techniques applied to structures into which a heavy atom had been artificially introduced by chemical methods Photographs of diffraction patterns from single crystals have enabled the broad outlines of the structure to be determined and a model of the polypeptide chain to be built up It is hoped next to determine the detailed atomic positions within the structure by more sophisticated techniques These techniques will involve processing very large amounts of data, some thousands of reflexions being obtained from the X-ray apparatus

All these must be included in the refinement calculations, which result in the tabulation of electron density values over a hundred or more two-dimensional Fourier sections through the crystal, each section involving evaluations at many hundreds of points The processing will thus require not only very rapid calculation facilities, but also adequate supporting equipment for input of data and output of results Furthermore, myoglobin is one of the simpler protein structures, so that future advances in this field will undoubtedly require the fastest and largest equipment available

Developments in very fast computers were described in a crowded session by Drs T Kilburn (Manchester), M Lehmann (Israel), and N C Metropolis (Chicago) Dr Kilburn described the *Muse* project, which is now in an advanced stage of planning, to build a computer at the University of Manchester with speeds of operation in the millimicrosecond range This machine, like most other modern developments, will rely primarily on transistors and magnetic cores as fundamental elements for storage, arithmetic operation, and control The arithmetic unit, a prototype of which has been built and is now being tested, is capable of carrying out multiplications and additions on numbers in floating point representation in less than 2 microseconds, and administrative instructions will be carried out in less than 1/5 μsec The main storage is to be on magnetic cores, with an access time of 2 μsec However, overlapping of operations in some parts of the machine will reduce the effective access to ½ μsec In addition, a special store is also provided from which words can be read in about 1/7 μsec , but into which writing is restricted A wide use of time sharing is to be made in controlling input, output and bulk storage mechanisms, such as magnetic tapes Up to 16 magnetic tapes and, in addition, up to 16 slower mechanisms can be feeding into or be fed by the computer simultaneously, the computer control scanning these units in sequence at a pace sufficiently rapid to allow inspection of each one at a suitable interval

It is hoped that this very powerful machine will be working in just over two years time, and that copies will later be available commercially

Dr Lehmann described a fast but comparatively small computer which is being designed for the Israeli Ministry of Defence This will include an 8,000-word drum and a core store of 128 words, and is expected to be very cheap to produce, although comparable in speed with many of the large machines of to-day, which cost hundreds of thousands of pounds

Dr Metropolis described the computer being developed at the University of Chicago under his direction This machine is to be in the same speed-range as the

Muse, but is not planned, at present, on quite such a large scale. Nevertheless a core store of more than 8,000 words with an access time of 2 µsec is to be provided and there is provision for at least four magnetic tape mechanisms to be attached to the machine. Two very interesting features are the proposed structure of the arithmetic unit and a new method of number representation it is intended to incorporate. The arithmetic unit is to be built on the same principle as that of the *Maniac* at Los Alamos, using asynchronous circuitry, but will include many additional cross-connexions between registers to facilitate rapid arithmetical working. A number representation, called 'significant digit' representation, will be used. This is a form of floating point representation which avoids the appearance of many meaningless digits at the end of approximate numbers, while retaining a few guarding digits against rounding errors.

An important application of fast machines is to problems in supersonic flow-past aerofoils and other surfaces. An interesting contribution to this subject was made by Mr. D. S. Butler of the Armaments Research and Development Establishment who described some recent work he has carried out on this problem.

In order to calculate the lines of flow around and pressures on a solid figure in a supersonic airstream it is necessary to solve a hyperbolic partial differential equation in three variables. He discussed various methods of doing this and made particular reference to the method of characteristics, a powerful technique for solving equations of this type. He went on to describe a particular example of stationary flow around a body shaped like a delta-wing aircraft and showed how the calculations had been carried out in this case using the computer at Fort Halstead, a Ferranti Mk. 1*.

Other topics at the conference which excited considerable interest concerned the control of production in factories and the application of operational research techniques to this and allied problems. Mr. F. Bryen of Imperial Chemical Industries described an application of punched card machinery to factory control, and Mr. J. Harling of Urwick, Orr and Partners dealt very interestingly with the use of computers for operations research. An application of one of the latter techniques within the Shell group of companies formed the subject of a later address by Mr. C. S. Galer. There were also sessions on keeping accounts by computer, on auditing the accounts so kept, on the training and selection of programmers, on automatic programming, and on working experience with magnetic tape mechanisms. On the mathematical side, Dr. A. S. Householder of the Oak Ridge National Laboratory, Tennessee, directed attention to some of the pitfalls in the techniques commonly used on computers. In particular, he considered the stability of two methods of inverting a matrix, and concluded that the method of rotation is not more stable than the method of elimination, although an argument can be adduced to the effect that it is. After this paper, as after all the formal papers presented, there was a lively discussion, in which many of the delegates took part.

A wide-ranging review of the state of the computing art was given by two speakers: Mr. J. A. Goldsmith of Robson, Morrow and Co., and Dr. A. S. Douglas of the University of Leeds. Mr. Goldsmith noted that delivery of 76 installations of electronic computers had so far been made in the United Kingdom and that 33 were on order, although recently the tempo of orders had slackened. Much of the work in the commercial field had so far been unambitious and the results somewhat disappointing. He felt that it would be 5–10 years before computers played a full part in helping management to control their organizations. Dr. Douglas reviewed the work of computers in British universities. Much work has been done in training in their use at the postgraduate-level, and he felt that this could well be extended to the undergraduate-level. He discussed the problem confronting universities in the installation and use of large-scale machinery, and suggested that it would be desirable for three or more of the large fast computers such as *Muse* to be installed in universities, where they would act (on a service basis) as focuses for local computer users. He gave details of serviceability and use of typical present-day university installations, and concluded that a high standard of efficiency can be attained.

All the sessions were very well attended throughout. It is intended in the future to hold annual conferences of the Society at various centres in the United Kingdom, the next conference being planned for June or July 1960. A. S. DOUGLAS

THE INTERNATIONAL INSTITUTE OF REFRIGERATION

THE first International Congress of Refrigeration was held in Paris in October 1908. Shortly after this, in January 1909, the International Association of Refrigeration was established, following the suggestion of Kamerlingh Onnes, the name being changed to the International Institute of Refrigeration just after the First World War. The organization has therefore just celebrated its jubilee.

The general objective of the Institute is the development of the science and techniques of refrigeration in the international field. It promotes scientific research, as well as the teaching and popularization of refrigeration and its application in all fields, particularly in food preservation, health and industrial processes. The International Institute of Refrigeration headquarters are in Paris.

The main tasks of the Institute are determined by the general conference, at present presided over by Dr. Ezer Griffiths. This meets every four years, at the same time as an International Congress of Refrigeration, also organized by the Institute. Executive power is vested in an executive committee. A technical board, of which Dr. J. C. Fidler is the current president, co-ordinates the scientific and technical activity of nine commissions, which between them cover all aspects of refrigeration matters from fundamental research to applications in agriculture, transport, etc.

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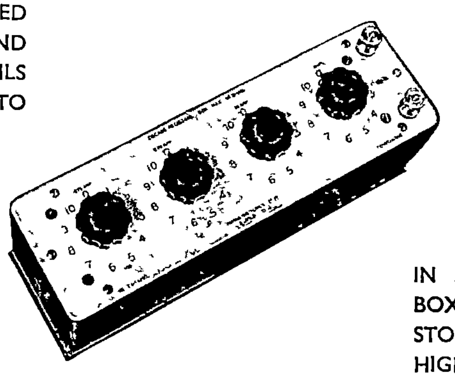

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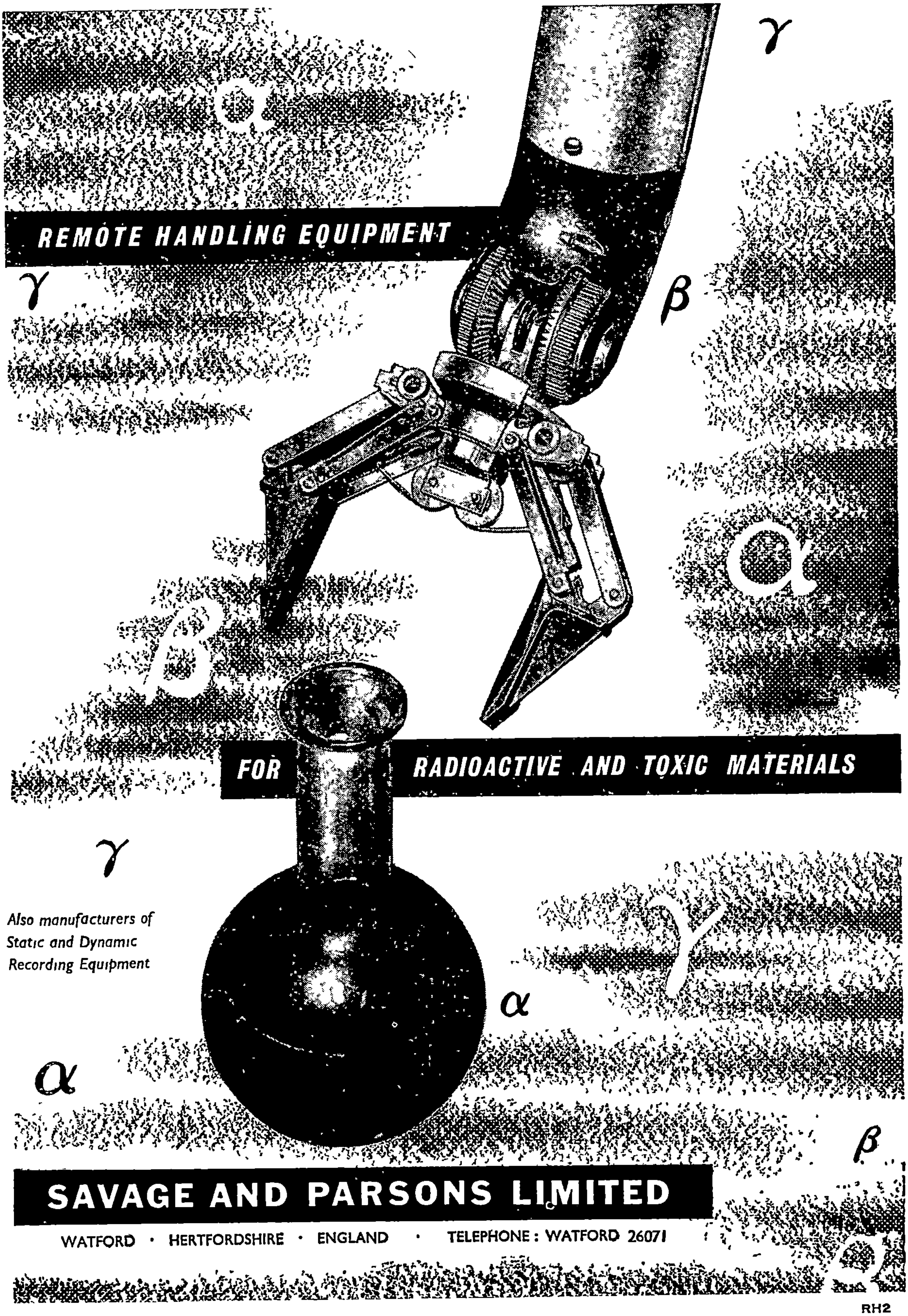

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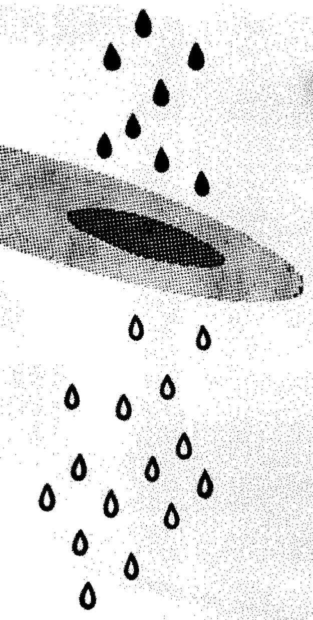

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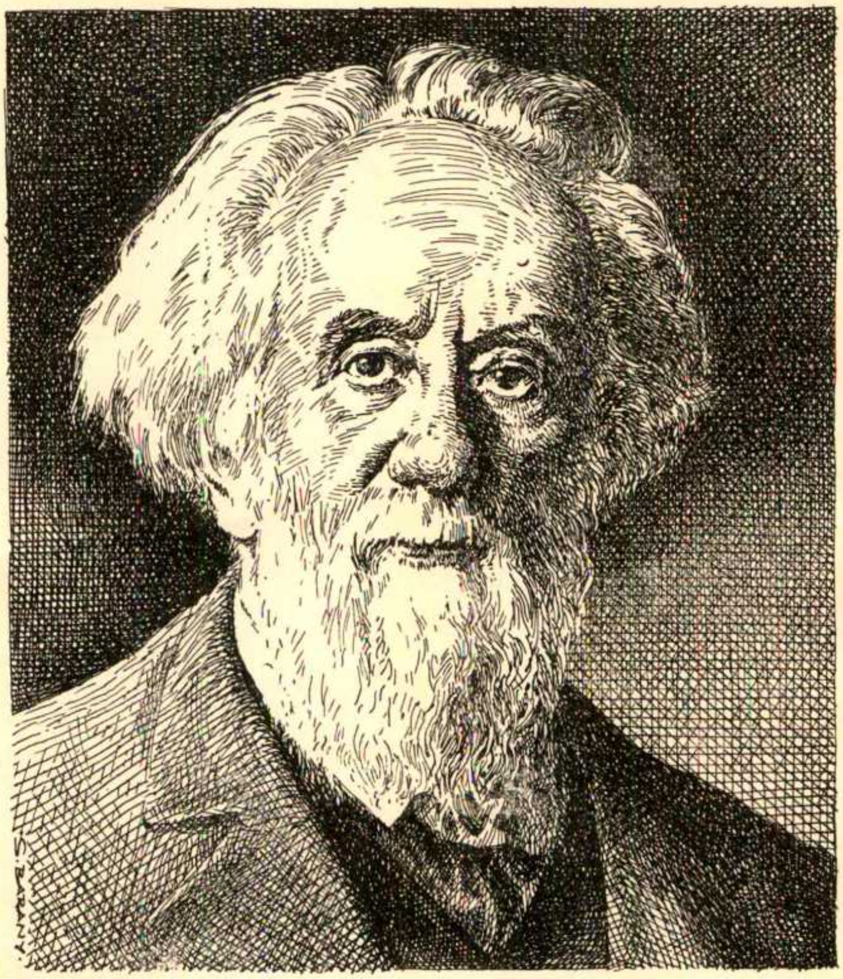

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papers were discussed at plenary sessions and at meetings of all the commissions held during the period of the Conference

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STERIC ASPECTS OF THE CHEMISTRY AND BIOCHEMISTRY OF NATURAL PRODUCTS

THE interest taken in stereochemical problems by chemists and biochemists alike has been greatly increased in recent years, and the Biochemical Society recognized this fact by arranging a symposium on "Steric Aspects of the Chemistry and Biochemistry of Natural Products", which was held in the Senate House of the University of London on June 30 The chairman of the morning session, Prof A Neuberger (London), discussed some of the main trends of recent work in this field and emphasized the importance of stereochemistry in modern enzymology

Dr W Klyne (London) then discussed in a comprehensive manner the types of evidence used for establishing relative or absolute configurations of asymmetric compounds The term 'absolute configuration' can now be used with confidence, as Bijvoet and his colleagues working in Utrecht have demonstrated by means of a special X-ray technique that the Fischer convention for glyceraldehyde happens to be correct Dr Klyne pointed out that the most satisfactory method of correlating two asymmetric compounds is by a chemical reaction which does not involve the asymmetric centre The second type of approach is concerned with chemical reactions in which one or more of the linkages of the asymmetric atoms are broken The stereochemical correlation in this situation must be based on kinetic and other evidence and must involve certain assumptions about the mechanisms of the substitution concerned

Dr Klyne then went on to discuss the deductions which can be made from studies of asymmetric synthesis, methods used successfully by Prelog and by Cram Another type of approach which was developed mainly by Fredga in Sweden, and which is probably not sufficiently widely known, is based on the study of melting points of mixtures of a compound of known configuration and a structurally similar compound of unknown configuration If the two compounds have opposite configurations they may form in the solid phase a quasi-racemic compound, and this can be deduced from the melting-point curve

Reference was also made to the information obtained from the applications of X-ray analysis, especially to compounds with more than one asymmetric centre Finally methods were discussed which depend on a numerical comparison of the values of optical rotations of structurally related compounds These calculations and deductions have in the past been largely based on measurements at a single wave-length and have indeed yielded much valuable information In recent years this tool has been made more powerful by extending the measurements to the whole visible and a large part of the ultra-violet range of the spectrum In this development (rotatory dispersion), Djerassi of Detroit has taken the leading part

Steric aspects of the biosynthesis of terpenes and steroids were considered by Dr D Arigoni (Zurich), who discussed first the formation of an isopentane derivative from acetate The early stages of the synthesis consist of a condensation of acetoacetyl-CoA with acetyl-CoA to give the CoA derivative of β-hydroxy-β-methylglutaric acid The latter is then reduced, probably through the aldehydo acid, to β,δ-dihydroxy-β-methylvaleric acid or mevalonic acid The absolute configuration of this compound has been unambiguously related recently by Eberle and Arigoni to that of quinic acid, which in turn had been established by Dangschat and Fischer in 1950 by relating it to glyceraldehyde Dr Arigoni then referred to the stereochemical problems involved in the conversion of leucine to β-hydroxy-β-methylglutaconic acid, which occurs through the CoA esters of β-methylcrotonic acid and β-methylglutaconic acid The hydration of the double bond and the carboxylation of methylcrotonic acid must be stereospecific and this is also likely to apply to the reduction of mevaldic acid to mevalonic acid The next steps in the reaction sequence are the simultaneous decarboxylation and elimination of the tertiary hydroxyl group from the pyrophosphate of mevalonic acid to give isopentenyl pyrophosphate and the isomerization of the latter to give dimethylallyl pyrophosphate , it can be postulated that the isomerization is stereospecific and Dr Arigoni thought it probable that only one of the two hydrogen atoms of isopentenyl pyrophosphate is involved in the isomerization

The allyl compound is assumed to react with the isopentenyl pyrophosphate, resulting in the formation of a new C—C bond This reaction must again have stereospecificity, since the new double bond produced usually has a *trans* configuration , but Dr Arigoni stressed the fact that the detailed mechanism of the formation of this condensation is not yet securely established and he suggested that experiments involving labelling with deuterium and determining the axial or equatorial position of the deuterium in a suitable cyclization product are likely to give further information.

Dr Arigoni pointed out that steric factors had to be taken into account in any attempts which were made to explain the actual cyclization and the rearrangements which either follow the cyclization proper or are coupled with it Otherwise, it would be difficult to explain the formation of diastereoisomers from one single aliphatic precursor, squalene If a carbonium ion is involved in cyclization reactions, it can only have a structure which preserves the original configuration , a 'bridged ion' fulfils this requirement and addition of this relatively stable species to a base or nucleophilic substance ('antiplanar addition') will produce only one isomer The postulate of antiplanar addition imposes restrictions on the type of folding and it appears that only the chair-type and boat-type of folding explain, for example, the formation of both lanosterol and tirucallol from *all-trans* squalene Experimental evidence for the theory is provided by the work of Bloch and by that of Cornforth and Popják Further interesting examples from the work of Dr Arigoni himself and from that of Prof Birch were given, showing the application of stereochemical rules to the biogenesis of terpenes, but a note of caution was sounded against the assumption that the configuration of the *A*/*B* ring junction is always the same

Steric aspects of drug action were discussed by Dr R B Barlow (Edinburgh), who began his talk by emphasizing the distinction first made by Stephenson between affinity or adsorbability of a drug to a receptor site, and efficacy, that is, the ability of the adsorbed drug to start a sequence of reactions which can be observed in a pharmacological experiment While it is possible to make definite statements about the steric arrangement of drugs, ideas on the stereochemistry of receptors are generally based on somewhat uncertain deductions made from structures of active compounds and those of their antagonists

Dr Barlow illustrated his talk with examples from the field of drugs resembling acetylcholine either in its muscarine-like or nicotine-like function or of compounds antagonizing such action For nicotine-like activity the molecule should contain a cationic head such as a dimethylamino or trimethylamino group and a partial positive charge at a distance similar to that which separates the ether oxygen of acetylcholine from the charged nitrogen atom In nicotine itself the two optical isomers have identical pharmacological activities The constitution and stereochemistry of muscarine have recently been worked out and it is found that it has three centres of asymmetry Dr Barlow then discussed the activities of the various stereo-isomers of muscarine and of various synthetic substrates resembling this substance pharmacologically, such as acetyl-β-methylcholine In this case the (+)-isomer is reported to be about 200 times as active as the (−)-isomer Dr Barlow then mentioned the importance of steric factors in flexible molecules and he pointed out that in these cases it is more difficult to arrive at quantitative conclusions In particular, the work of Schueler was discussed in detail and some recent criticisms of his calculations were mentioned Dr Barlow then dealt in some detail with di-quaternary bases, such as various esters of aliphatic dicarboxylic esters containing two quaternary basic groups, such as suxamethonium The many examples which were considered illustrated the difficulties which still exist if one attempts to correlate the stereochemistry of the compounds under consideration with their biological activity

The last paper of the morning session was given by Dr G A J Pitt (Liverpool) on behalf of Prof R A Morton and himself, and dealt with *cis-trans* isomers of retinene in visual processes Dr Pitt briefly discussed the chemistry of retinene (vitamin A aldehyde) and that of vitamin A, and in particular referred to the early work of Pauling which predicted the existence of the following four isomers all-*trans* , 9-mono*cis* , 13-mono*cis* , and 9 13-di*cis* These four isomers of retinene and vitamin A have been synthesized, but it has been possible to prepare two other retinenes and vitamins A containing a *cis*-linkage in the 'hindered' 11-position No 7-*cis* vitamin A has yet been prepared and it seems almost certain that 7-*cis* isomers cannot exist, as in such a molecule there would be considerable steric interference Dr Pitt then referred briefly to the occurrence of *cis*-isomers in Nature, and mentioned that the thermodynamically most stable isomer and the one found most commonly in Nature is the all-*trans* isomer He then reviewed the isomerization of the various retinene isomers and their absorption spectra The importance of the *cis-trans* isomerization was appreciated when Hubbard and Wald found that the retinene which united with opsin was the 11-*cis* form The 9-*cis* form also reacted with opsin but the resulting complex has not been found in Nature The main effect of the introduction of a *cis*-bond at the 11-position is that it produces a bend of the side-chain whereas in the all-*trans* isomer the side-chain is straight When rhodopsin is illuminated it breaks down to the protein opsin and a retinene, but the latter was found, rather surprisingly, to be the all-*trans* isomer This all-*trans* retinene liberated by the bleaching of rhodopsin does not give rhodopsin again when mixed with the opsin *in vitro*, and strong evidence has been obtained by Hubbard that the utilization of the *trans*-isomer in a more complex system is caused by the presence of an enzyme called retinene isomerase, which changes the all-*trans* retinene to the 11-*cis* isomer Dr Pitt discussed this enzymic isomerization in more detail and then went on to report on recent work which has been done on invertebrate rhodopsins, dealing in particular with indicator yellow He also gave an account of the effect of light on various rhodopsins under a variety of conditions, but it would be impossible to summarize adequately the rather complicated relationships which have been established, mainly due to the work of Hubbard and Wald

The chair was taken for the afternoon session by Prof S Peat (Bangor) , all three papers were devoted to various aspects of stereospecificity in enzyme action Dr E C Webb (Cambridge), who dealt with hydrolytic enzymes, treated some general matters relevant to all enzymes He emphasized that enzymic catalysis is at least a two-stage process, and that steric factors may be important both in the formation and in the breakdown of the intermediate enzyme-substrate complex To be of real value any comparison of substrates should involve measurement of both the Michaelis constant (K_m) and the reaction velocity, as measures of the two stages

Examples considered included *ali*-esterases and lipases, cholinesterases, glycosidases, lactonases, peptidases, arginase and fumarase For the cholinesterases knowledge has accumulated which permits the representation of the catalysis in terms of anionic and esteratic sites on the enzyme surface The high specificity of glycosidases is well known, and this is paralleled in the recently studied group of lactonases Proteolytic enzymes may be used, thanks to their high stereospecificity, as tools for the resolution of synthetic amino-acids Work on the behaviour of synthetic substrates as competitive inhibitors of α-chymotrypsin emphasizes the importance of distinguishing the two stages of enzyme action

In conclusion, the importance of Ogston's concept (1948) of three-point attachment between enzyme and substrate was emphasized This idea explains very simply the formation from a symmetrical substrate (CX_2YZ) of an asymmetric product (CXX^1YZ) Ogston has recently discussed this concept further (1958)

Dr H Gutfreund (Shinfield) in discussion considered further the specificity of α-chymotrypsin, in the reactions of which three stages can be distinguished ($E + AB \rightleftharpoons E\text{-}AB \rightleftharpoons EA + B \rightleftharpoons E + A + B$)

Prof E C Slater (Amsterdam) dealt with oxidation-reduction enzymes He began by considering dehydrogenases which act on hydroxy acids and more complex systems which can (indirectly) transform one enantiomer into the other (commonly but wrongly called racemases) After a brief discussion of amino-acid oxidases the greater part of the paper was devoted to stereospecificity of hydrogen transfer in the reactions of pyridine nucleotide dehydrogenases These compounds are dinucleotides, one unit of which is the nicotinamide group which can undergo reversible oxidation and reduction at N and C–4 The elegant work of Vennesland's school in Chicago using substrates and enzymes labelled with deuterium has shown that these dehydrogenases fall into two classes , these are distinguished by the fact that they add hydrogen at C–4 of the diphosphopyridine nucleotide molecule on opposite sides Other related work dealt with reactions involving cytochrome *c*, flavin and orotic acid

An important extension of Vennesland's work was the preparation of stereospecifically labelled and optically active CH_3 CHDOH Alternative mechanisms of action for a typical dehydrogenase have been suggested by Dixon and Webb in their classic textbook on "Enzymes", and by Van Eyk, Kaplan *et al*

Finally, succinic dehydrogenase, which involves another type of stereospecificity, was introduced

Dr H R Levy (Chicago) emphasized in discussion that the stereospecificity in the reactions of pyridine nucleotides is another example of the ability of enzymes to distinguish between two identical groups, and gave further examples Dr W Klyne directed attention to the important work of Prelog on microbiological oxidations and reductions of simple decalones and related compounds The pictorial treatment of these reactions may constitute a valuable extension of Ogston's concept of three-point attachment

Dr G R Barker (Manchester) dealt with enzymes of nucleotide metabolism He began by outlining current views on the biosynthesis of D-ribose and 2-deoxy-D-ribose , the important routes leading to ribose involve the 5-phosphates of D-xylulose and D-ribulose The formation and fission of glycosidic bonds in nucleosides was next considered , these reactions are generally phosphorolyses and not hydrolyses The stereochemistry of analogous chemical syntheses of nucleosides has been studied with respect to relative configurations at C–1 and C–2, and it is necessary to consider how far the stereospecificity of the enzymic reaction is attributable to the enzyme, and how far it is inherent in the nature of the reaction catalysed The answer at present is that both factors are involved

The formation and fission of internucleotide links in polynucleotides were then discussed Pancreatic ribonuclease degrades ribopolynucleotides via nucleoside 2′,3′-(cyclic)-phosphates to 3′-phosphates, and the steric factors involved in this and the reverse reaction were considered Finally, the polynucleotide phosphorylases were considered , many reactions require a polynucleotide 'primer', the composition of which determines that of the polymer formed , this is a direct demonstration that the primer acts as a template

All three papers emphasized in different ways the essentially complementary nature of enzyme and substrate and the two (or more) stage character of the enzyme-substrate reaction

A NEUBERGER
W KLYNE

OIL IN NAVIGABLE WATERS

IT is now seven years since a group of representatives of the interests in Great Britain which are most affected by oil pollution formed themselves into the Co-ordinating Advisory Committee on Oil Pollution of the Sea, under the chairmanship of Mr James Callaghan, M P In 1953 this Committee organized an international conference in London which called for a meeting of governments of all maritime countries to take action to prevent the growing pollution of the oceans of the world This request met with considerable success, for an inter-governmental conference was held in 1954, at which an international convention was drawn up This Convention came into force in July 1958, and has been ratified by the United Kingdom, Belgium, Canada, Denmark, Finland, France, the Federal Republic of Germany, the Irish Republic, Mexico, the Netherlands, Norway and Sweden

The Convention does not prohibit the discharge of waste oil entirely, but merely within certain zones, and the countries which observe the Convention represent only about one-half of the world's tanker shipping, notable omissions being the United States, U S S R , Poland, Italy, Panama and Liberia The Co-ordinating Advisory Committee on Oil Pollution of the Sea therefore decided to organize an international conference to discuss, among other aspects, how far the 1954 Convention had been effective in diminishing the contamination of coasts and beaches, and the destruction of bird life This Conference was held in Copenhagen during July 3–4 It was presided over by Mr James Callaghan, M P, with Dr Bøje Benzon (chairman, Danish National Section, International Council for Bird Preservation) and Hr Ekspeditionssekretær Sven Lunddahl (Secretary, Danish Council for the Prevention of Oil Pollution of the Sea) as vice-chairmen

The meeting was very well attended, and included a wide range of interests, for among those present were representatives of government departments of transport and commerce, ship owners, port authorities, ship repairers, seamen's unions, sea-fisheries associations, local authorities, pleasure resorts, tourist organizations, hotel and restaurant associations, and conservation, ornithological, and humanitarian organizations, of many countries, together with the diplomatic representatives of nineteen nations In addition, seven international bodies, the Intergovernmental Maritime Consultative Organization, the Food and Agriculture Organization, the Council of Europe, the International Union of Biological Sciences, the International Council for Bird Preservation, the International Union for the Conservation of Nature and Natural Resources and the World Federation for the Protection of Animals were represented

The Conference was opened by Mr Helge Juul, deputizing for the Danish Minister of Commerce, and the first section of the proceedings was devoted to a review of the situation arising from the 1954 intergovernmental Conference In a paper on the working of the Oil in Navigable Waters Act, 1955, Mr D C Haselgrove, under-secretary, U K Ministry of Transport and Civil Aviation, pointed out that the provisions of this act go beyond the basic requirements of the 1954 Convention, and quoted as an example that the sea zones in which British ships registered in the United Kingdom must not discharge oil extend beyond the zones laid down in the Convention He paid a warm tribute to the ready co-operation of British ship owners, dock and harbour authorities, and the oil industry Capt K C Angus, Marine Regulations Branch, Department of Transport, Canada, in a report on the preventive measures taken by the Canadian Government, stated that the coasts of Newfoundland suffered most from oil pollution, and after them the eastern maritime provinces and the St Lawrence river, but the whole Atlantic coast was subject to heavy and habitual contamination He stressed the value of weight of public opinion, and directed attention to the fact that in many countries only a very small percentage of the population was aware of the existence of oil pollution and its serious consequences Mr Lester A Giles, jun, American Humane Education Society, in association with Mr John W Mann, State Department, Washington, D C, announced that an inter-departmental Committee had unanimously adopted a draft report for submission to the Secretary of State, recommending that the United States accept the 1954 Convention with reservations of a technical nature, a statement that was received with acclamation

In a paper dealing with the working of the Convention from the point of view of British tanker and oil companies, it was recalled that since the Second World War the use of oil, and consequently the number of tankers, had increased enormously, and that ownership was now spread over a great variety of flags, some quite new to shipping, and it was urged that universal ratification be strenuously pursued In the discussion regarding methods of cleaning cargo tanks which followed, Mr A Logan (Shell Tankers, Ltd) uttered a word of warning regarding the indiscriminate use of chemicals, and pointed out that the use of large amounts of detergent might lead to a situation even more destructive and less manageable than that arising from the original oil-sludge

Disposal of oil waste and facilities in ports were dealt with by speakers from Denmark, the Netherlands and the United Kingdom Mr S Glazenburg (Netherlands) forecast that the consumption of 134 million tons of oil by European countries in 1957 would rise to a consumption of 190 million tons in 1963 and 340 million tons in 1975, with a corresponding expected rise in refinery capacity, particularly in Western Europe Comparatively more oil products would be exported from Western Europe, and in proportion to this increase in oil movements the problem of the disposal of oil residues would become more acute

Speaking for 43 coastal municipalities in the Netherlands the Burgomaster of Bergen described the system of weekly reports on the condition of the beaches in Holland, which are summarized annually in order to give a general survey of the amount of oil pollution during the year He urged that municipalities in other countries should organize similar surveys and that the information should be co-ordinated on an international scale. From the point of view of tourism it was pointed out by Mr Eric D Croft, director-secretary of the British Hotels and Restaurants' Association, that dollar earnings from tourism exceed the total value of exports of cars and Scotch whisky together from the United Kingdom to the United States, and he stressed the serious loss to the tourist trade presented by pollution of beaches

Reports, on the destruction of birds by waste oil, received from Canada, the German Federal Republic, the Netherlands, Newfoundland, Poland and the United Kingdom, showed that in the Netherlands it was estimated that a minimum of 20,000 and a maximum of perhaps 50,000 birds are destroyed annually, and that 50 different species have been affected, in Newfoundland all species of sea-birds around the coasts are victims, further evidencing the great toll of sea birds which has been continuing for more than forty years

Major Bertil Funck (Sweden) directed attention to the recurring pollution of the Baltic, especially east and south-east of the island of Gotland Under the Convention there is an area in the Baltic, south-east of Gotland, 50 nautical miles from the island and the mainland, where discharge of oil is permitted He epmhasized that the Baltic is too small in area for oil discharge, and proposed that a resolution be passed seeking to obtain the inclusion of the Baltic as a prohibited zone for oil discharge He also recommended that the whole North Sea should similarly be declared a prohibited zone

The representative of the secretary-general of the Inter-governmental Maritime Consultative Organization, Kommerseraadet G M E Boos, stated that the bureau functions for the International Convention for the Prevention of Pollution of the Sea by Oil had been discharged by the United Kingdom up to June 15, 1959, when the Organization took over the duties and obligations conferred upon it under the terms of the Convention Among other responsibilities the Organization would have the duty of convening a further conference to review both the working of the Convention, and the possibility of bringing about complete cessation of discharge of persistent oils into the sea In resolving to take over its functions, however, the Organization pointed out to the governments concerned that, owing to other urgent tasks, it would not be possible to convene a further conference before 1961 Mr Boos ended on a personal note, stating that though the convening of a further conference on oil pollution was not an obligation made under the Convention, he would characterize it as a moral undertaking inspired by the first resolution of the 1954 Conference The aim of that resolution was certainly the same as the object of the present conference, namely, the complete avoidance of discharge of persistent oils into the sea, which, so far as was known, was the only entirely effective method of preventing oil pollution

Two resolutions were adopted by the conference The first urged that the governments of countries which had not yet ratified the Convention of 1954 should do so , that further efforts should be made to impress upon governments and upon ship owners and ship's officers and crews the serious consequences arising from the discharge of oily wastes into the sea , that all necessary facilities be provided for the disposal of oily wastes in main ports and harbours , that technical research into means of avoiding discharges of oily wastes into the sea be intensified, and the results made widely known through the Inter-governmental Maritime Consultative Organization , that with a view to achieving the aim of total avoidance of the discharge of persistent oils into the sea, the governments and the Organization should make preparations for holding a further inter-governmental conference as soon as possible

The second resolution, though reiterating the only effective solution of the problem, proposed in the meantime an extension of the prohibited zones for oil discharges in such areas as the Gulf of St Lawrence, the Grand Banks of Newfoundland, and the eastern seaboard of North America, and also in the Baltic and North Seas P BARCLAY-SMITH

RADIOACTIVATION ANALYSIS

NEW methods of chemical analysis using techniques derived from nuclear physics were discussed at a Symposium on Radioactivation Analysis held in Vienna during June 1–3 Sponsored by the International Atomic Energy Agency and the International Council of Scientific Unions, the meeting brought together research workers from twenty-one countries for the first international conference on a subject of rapidly growing importance in many branches of science, medicine and industry

An introductory survey by G B Cook (Atomic Energy Research Establishment, Harwell) was followed by reviews of the uses of activation analysis in geochemistry (W. Herr, Max-Planck Institute of Chemistry, Mainz), biochemistry and medicine (J M A Lenihan, Western Regional Hospital Board, Glasgow) and metallurgy (J Hoste, University of Ghent) P Leveque (Centre d'Études Nucléaires, Saclay) spoke of applications in industry and G W Leddicotte (Oak Ridge National Laboratory) described recent developments in the United States Several shorter contributions were also given

Most analytical methods depend on the behaviour of electrons Activation analysis depends on the properties of the nucleus, in particular the radioactivity induced by bombardment with neutrons or other particles Many elements have isotopes which decay slowly enough for the assay to be done a day or two after irradiation, but work on short-lived activities can only be done close to a neutron source A reactor is the instrument of choice for activation analysis, but more modest facilities are often serviceable Discharge tubes using the deuterium–tritium reaction give neutron fluxes as high as 10^9 n/cm ^{2}/sec at moderate cost Useful work has been done with the lower fluxes provided by radium–beryllium or antimony–beryllium sources , a recent innovation is the americium–beryllium source, which has the merit of freedom from residual γ-ray emission

Since nearly seventy elements become appreciably radioactive after a few hours exposure inside a nuclear reactor of moderate thermal neutron flux (10^{12} n/cm ^{2}/sec), the irradiated sample generally contains several different activities Fortunately many of the common matrix elements (aluminium, silicon, iron, carbon, nitrogen, oxygen) have relatively small cross-sections for thermal neutron capture Differences in half-life and decay energy between trace element and matrix or between different trace elements in the sample are also advantageous

The isolation of individual activities for radioactive assay may often be achieved by γ-ray spectroscopy, but a preliminary chemical separation is generally advisable, even when dealing with short-lived nuclides When once the experimental material has been irradiated, along with a known amount of the element under investigation (to serve as a standard), the isolation may be simplified by the addition of stable carrier in any desired amount Another useful advantage of the activation method is that contamination of reagents, often a source of trouble in the micro-determination of trace elements, need not be considered at all

The sensitivity of thermal neutron activation analysis for trace estimation is remarkable Many elements can be estimated at levels of 10^{-8} to 10^{-11} gm using a neutron flux of 10^{12} n/cm ^{2}/sec acting on a 1-gm sample The detection of trace elements by this method has been useful in several industrial problems, notably the measurement of deliberate or fortuitous contamination in semi-conductor materials Applications in the oil industry are so numerous (and so important financially) that many companies have acquired neutron sources of their own A typical problem, in which conventional methods of analysis are not sufficiently sensitive, is the control of vanadium, which acts as a catalyst poison in cracking operations and as a corrosive agent in fuel oils

The same element is important in a different connexion as a constituent of high-alloy steels Here the activation method of analysis is valuable for its speed and accuracy A 10-second irradiation, at a flux of 10^{10} n/cm ^{2}/sec , is sufficient for analytical determinations using the isotope vanadium-52 (half-life 3 8 minutes) In prospecting for vanadium, a useful technique is to lower into a borehole a neutron generator. After a few minutes the generator is replaced by a scintillation counter to estimate the vanadium-52 activity.

In geochemistry, where the study of natural radioactivity has been of prime importance for more than half a century, the new possibilities offered by activation analysis have been welcomed. A powerful technique for age determination in rocks and meteorites depends on measurement of the relative abundance of parent and daughter nuclides in a natural radioactive decay process. Useful improvement in sensitivity can be expected where one or both of the nuclides can be subjected to activation analysis. Potassium/argon and rubidium/strontium ratios are readily measured in this way. Uranium-238 can be estimated down to a limit of 10^{-12} gm. by the reaction ^{238}U(n, $\gamma\beta$)^{239}Np. For uranium-235 the limit of sensitivity so far achieved (at the Argonne National Laboratory) is 5×10^{-11} gm., using the reaction ^{235}U(n, f)^{140}Ba.

Activation analysis of biological material has attracted relatively little attention, though the method has many interesting potentialities. Several elements, including vanadium, manganese and cobalt, are important to plants or animals but their function in human nutrition is still obscure, through lack of sufficiently sensitive analytical methods. The role of vanadium in dental caries and of manganese in bone formation were two of the subjects suggested for study by activation analysis. Many problems in dental science and in animal biochemistry are also awaiting exploration by activation methods.

Arsenic is an element of continuing interest in clinical science, partly because of its increasing uses and hazards in agriculture and partly because it is the only component of tobacco smoke known to be carcinogenic in man. Arsenic-levels in normal tissue are too low for accurate estimation in living subjects by conventional methods. Activation analysis has been used in several investigations of arsenic poisoning, whether accidental or homicidal. An unusual toxicological experiment was the recent study by activation analysis of the remains of Erik XIV, a sixteenth-century Swedish king who died in mysterious circumstances. These tests gave support to the theory that he was poisoned by mercury, said to have been administered in a dish of pea soup.

Although thermal neutrons are the most versatile agents for activation analysis, fast neutrons have some distinctive applications. The estimation of traces of oxygen has been done satisfactorily by mixing the experimental sample with lithium fluoride and irradiating with fast neutrons to produce the reaction ^{6}Li(n α)^{3}H followed by ^{16}O(^{3}H, n)^{18}F (half-life 112 min.). The limit of sensitivity of this method, as practised at Harwell, is 5×10^{-7} gm. of oxygen. Protons have been used for the estimation of boron in silicon, a test of considerable importance to transistor manufacturers. Neutron activation yields no suitable isotopes but fast protons induce the reaction ^{11}B(p, n)^{11}C (half-life 20.4 min.). The silicon provides an internal standard by the reaction ^{30}Si(p, n)^{30}P. Concentrations of boron as low as 1 in 10^{9} have been measured in this way. Proton activation is useful also for the estimation of boron in germanium. Deuterons provide the best method for the estimation of magnesium in iron, by the reaction ^{24}Mg(d, α)^{22}Na. An internal standard is given by the reaction ^{56}Fe(d, α)^{54}Mn.

Two conclusions emerged from the symposium. The first is that any laboratory using conventional methods of chemical or spectrographic analysis would do well to explore the possible advantages of activation methods for some of its work. The second is that activation analysis, though superficially a simple technique, requires considerable skill in nuclear physics and in analytical chemistry for the full realization of its possibilities.

The success of the meeting was enhanced by the genial hospitality of the sponsors and by the agreeable atmosphere of the magnificent new conference suite of the International Atomic Energy Agency in the Hofburg. The proceedings of the symposium will be published shortly in book form. A long-awaited manual of experimental procedures is in an advanced state of preparation at Oak Ridge.

J. M. A. LENIHAN

THE CAPE TOWN SCIENCE EXHIBITION, 1959

ENCOURAGED by the success of the Science Exhibition held in Cape Town in March 1958, the Cape Council of the South African Association for the Advancement of Science, in collaboration with the Royal Society of South Africa, organized the second Science Exhibition in more spacious surroundings (10,500 sq. ft.) during the period April 6–11. After introductory addresses by the chairman of the Organizing Committee and vice-president of the South African Association for the Advancement of Science, Dr. Ronald Singer, and by H.M. Astronomer at the Cape, Prof. R. H. Stoy, the Exhibition was officially opened on the evening of April 6 before a distinguished audience of scientists, industrialists and educationists by His Excellency the Governor-General, Dr. E. G. Jansen.

Dr. Jansen stated that the Exhibition must be of particular interest to the layman, "because although one does not always understand all that science has to teach us, one realizes the importance of science and scientific research especially in the troublous times in which we live, and where science has, to a large extent, changed the life of civilized man and touches our everyday life at every point".

Dr. Jansen indicated that it is a rather startling thought that, according to some reports, the Soviet Union is more advanced than any other country, not only in certain fields of scientific research but also in the number of men and women receiving education and training in science and scientific methods. "The question arises as to whether sufficient is being done in that direction in our country. ... If we believe that the future of the country is in the hands of the youth of to-day, we should surely see to it that the education of our boys and girls is in the hands of men and women most fitted for the task, and who are devoted to their work. It follows that they should be adequately remunerated and enjoy fair conditions of employment."

The organizing committee produced a handsome brochure of 48 pages, providing not only a guide to the twenty-seven exhibits but also a general description of the scientific methods behind each exhibit. In the introduction, Dr. Singer stated that "the Exhibition is an attempt to present to the lay-public interesting aspects of modern scientific research and the application of science to industry and commerce. Some, if not most, of the important research projects and applications of research to industry in South Africa have been carefully assembled for the public of Cape Town and environs. A wider understanding of scientific endeavour and its vast potential will inspire lay individuals and give them some insight into the multitude of problems besetting almost every aspect of our daily lives—which we generally take for granted. Ignorance of these matters must only provide a false sense of security—an 'acceptance without contemplation' which can only end in a degeneration of our standards of civilization".

The exhibits (fixed at twenty-seven because of the limitations of space) were of three types—pure science, applied research and modern technical equipment. The South African Council for Scientific and Industrial Research presented a display depicting the nature and scope of its nine national research laboratories (roughly as outlined in *Nature*, 183, 853; 1959), a demonstration on the electrodialysis process for desalting water, and a poster-demonstration of the theme "The Planet Earth", emphasizing the international character of the recent International Geophysical Year. The methods of geophysical research were dramatically illustrated. The United Kingdom Information Office presented an impressive display outlining Britain's role in the development of power from the atom. Models of Calder Hall and *Zeta* provided the basis of the exhibit.

The Division of Fisheries presented its integrated programme of pelagic fish research, indicating the types of problem investigated and the directions in which the research has progressed. It clearly outlined the essential part it played in the £15 million fishing industry. In addition, the Fishing Industry Research Institute at the University of Cape Town provided an exhibit covering three aspects of its research—electrical thermometers on board ships, protein analysis and the bacteriology of fish.

The South African Broadcasting Corporation provided a unique studio to display the great deal of research and development work that lies behind a modern transmission system. The methods used to minimize distortion and noise were demonstrated. The South African Railways and Harbours' exhibits demonstrated centralized traffic control, the draught arrangement and problems in modern locomotives and the ultrasonic testing of materials.

The tellurometer microwave system of precise measurement of distance (an electronic device which measures distance between a master unit at one end and a remote unit at the other by phase comparison of a number of pattern frequencies) was invented in South Africa and is now used in many parts of the world. This was one of the exhibits by a number of industrial and commercial firms, including modern methods of sock-making, the scientific aspects of a modern motor-car, echo-sounders, industrial closed-circuit television, automatic alarm equipment on sea-going vessels, modern metal-spraying equipment, prevention of corrosion, atomic power in the oil industry, the bacteriology of canned foods, the standardizing of colours of printing inks, etc.

The South African Trigonometrical Survey exhibited the methods and techniques in modern survey operations. The Division of Entomology indicated the more important aspects of two of its research projects on forest and timber insects. Dr. S. H. Skaife exhibited his ingenious and simple equipment used in studying the habits and nature of some of the 400 species of ants in South Africa. The South African Museum's exhibit demonstrated a 14-ft. fibre-glass cast of a slab of rock containing the footprints of three mammal-like reptiles which lived 200 million years ago in Basutoland.

The South African Association for the Advancement of Knowledge and Culture displayed methods of promoting science education.

The most dramatic and most popular exhibit was that of the Department of Surgical Research of the University of Cape Town, which had a working heart–lung machine, and films and slide demonstrations on open-heart surgery. Approximately twenty people a day were treated for syncope by the St. John Ambulance Brigade.

Films of scientific interest were screened throughout the daily 12-hr. period when the Exhibition was open in a specially erected cinema inside the hall.

Approximately 17,000 people of all races visited the Exhibition, in comparison with 5,000 who attended the 1958 Exhibition. As a result of the sale of the brochure and the renting of exhibition space to commercial firms, more than £1,200 was collected. Most of this money will form the basis of a fund to provide scholarships to suitably qualified young men and women who wish to take up science as a career.

This Exhibition is part of an ambitious programme on which the Cape Council of the South African Association for the Advancement of Science has embarked during the past three years to stimulate an interest in and an understanding of the progress of modern science among non-specialists and laymen. The Council organizes four to five science film shows a month which attract capacity audiences, and, in addition, fortnightly luncheon film shows are put on at the South African Museum (where there is at present also a planetarium attracting visitors). Through the Council's initiative, refresher courses for science teachers are now regularly provided at the major South African universities, and at present the first in a series of autumn lectures (based on the Christmas Lectures in the United Kingdom) is being arranged for senior pupils at schools in and around Cape Town. Regular conversaziones are held, and last year the Council organized the Darwin–Wallace centenary week of exhibitions, lectures and symposia on evolution. A special committee is investigating science teaching, and particularly mathematics, in schools and making recommendations for improvement to the educational authorities. The formation of a Parliamentary and Scientific Committee is being mooted, and the Cape Council is already planning for the Diamond Jubilee Congress of the Association in 1962, when it hopes to invite distinguished scientists from overseas.

The Cape Council of the South African Association for the Advancement of Science firmly believes that in providing these services to the lay public it will eventually produce noticeable effects on the future leaders of not only science but also politics, religion, ethics and moral philosophy.

RONALD SINGER

THE PHYSICAL SOCIETY

THE contents of the 1958 Year Book of the Physical Society (pp v+106 London Physical Society, 1958 12*s* 6*d*), the fourth in the annual series, follows the pattern of previous volumes It contains the texts of the ninth Charles Chree Lecture, the thirteenth Holweck Lecture and the forty-second Guthrie Lecture , the addresses delivered by the recipients of the thirty-fifth Duddell Medal and the fourteenth Charles Vernon Boys Prize , the discourses given at the forty-second Physical Society exhibition of scientific instruments and apparatus , obituary notices of six fellows including Viscount Cherwell , and the report of the Council of the Society for 1957

In his Guthrie Lecture, Prof W E Lamb spoke about some experimental tests of quantum electrodynamics and explained how measurements of the fine structure of hydrogen and similar atoms by microwave methods have provided valuable information about the interactions between elementary particles and have stimulated theoretical calculations The Holweck Lecture, which was delivered by Prof A Abragam (Centre d'Études Nucléaires de Saclay) on May 1 at Cambridge, was entitled "Spin Temperature", and in it he showed by various examples how the concept of spin temperatures, positive or negative, is not only valid but also most fruitful The secular variation of the magnetic field of the Earth has been known for many years, but it is only recently that any reasonable theories for the variation have been developed In his Charles Chree Lecture, Sir Edward Bullard surveyed the experimental knowledge on the subject, and indicated that the theory that the variation is due to motions in an electrical conducting fluid core has much to commend it and is closely related to the dynamo theory of the origin of the main field

The measurement of the thickness of the helium film was the subject of the Duddell Medal address given by Prof L C Jackson He described how, in experiments at Bristol, a polarized light method used for the determination of the thickness of thin films of transparent materials was adapted to the measurement of the thickness of the helium film and how by a steady improvement in technique consistent observations were made of the helium-2 film as a function of height and temperature The Charles Vernon Boys Prize address, entitled "Development of Bubble Chambers and some recent Bubble Chamber Results in Elementary Particle Physics", is a verbatim account taken from a tape recording of Dr D A Glaser's talk which he delivered at Harwell on July 10, 1958

The lectures and addresses will interest all physicists, but they deal with specialist subjects The general reader will perhaps be attracted mostly by the discourses, and in particular by Mr M H Wilson's account of Goethe's colour experiments, which is illustrated by some coloured prints The other two discourses deal with some uses of physics in archæology (ultrasonic cleaning , proton magnetometry , optical, X-ray and gamma-ray spectrometry , and magnetic and radioactive dating), and some recent investigations with aircraft on the physics of clouds and rain

The Year Book is now the only publication of the Physical Society which is issued free to members It is a most valuable and well-produced volume, and it is hoped that it will continue to be issued, even when the proposed amalgamation of the Society with the Institute of Physics actually takes place S WEINTROUB

THE NATIONAL PHYSICAL LABORATORY

THE various changes in the work and organization of the National Physical Laboratory at Teddington, which have either taken place or are under active consideration, are outlined in the annual report (Report of the National Physical Laboratory for the year 1958 Pp viii+134+8 plates London H M Stationery Office, 1959 8*s* net), which has recently been published It contains the report of the Executive Committee, which was presented to the General Board at its meeting on May 28, one of the annual open-days of the Laboratory , detailed reports prepared by the respective superintendents, of the work of the nine divisions of the Laboratory , the names of members of the Board and its committees, and of the senior staff of the Laboratory , and lists of the various papers published by the director and members of staff during the year

In accordance with the recommendations of the review committee set up in 1957 to consider the organization and research programme of the Laboratory, the Electricity, Metrology and Physics Divisions were replaced by the three new Divisions of Applied Physics, Basic Physics and Standards Work on the differential analyser in the Mathematics Division , on refractories in the Metallurgy Division , and on glass working in the Light Division, has been discontinued In the Applied Physics Division the future of the high-voltage work has not yet been decided, but the testing of magnetic materials has been allowed to continue New projects in this Division are radiocarbon dating and the development of a national centre for neutron source standardization In the Mathematics Division increased emphasis is to be placed on theoretical physics, and with *Ace* now almost complete and in use by the Mathematics Division, the Control Mechanisms and Electronics Division has been re-orientated to new fields of research such as process control by computers that learn to make correct changes by trial and error methods, and the development of new components for very high-speed computers

No marked changes are contemplated in the research programmes of the Light, Metallurgy or Standards Divisions The principal change in the work of the Ship Division is that more attention will be given to problems connected with the sea-going qualities of ships in rough water Dr E Lee, previously director of operational research to the Admiralty, who was appointed to fill the new post of deputy director of the Laboratory, is expected to be of considerable assistance in connexion with the extension of the impact of the work and policy of the Laboratory on industry Dr J A Pople took up his post as superintendent of the Basic Physics Division on October 1 , work on the application of magnetic resonance to the study of the structure and properties of materials, on the physics of high polymers, and on the study of free radicals, is to be commenced in that Division

During 1958, sixteen scientific officers and twenty-three experimental officers were newly appointed, but although these represent record numbers there was no net gain in the total staff The hope is expressed in the annual report that foreign scientists will be attracted to come and work at the Laboratory for a few years as Research Fellows, and that more firms will second staff for periods of work at the Laboratory Contact with the universities was maintained, but no details of any extra-mural contracts with universities are given in the report Six members of university staffs were appointed as vacation consultants during the summer months, and nineteen vacation students worked at the Laboratory

Two open days were again held, and of the 7,900 people invited, 3,250 attended Two international symposia were held during the year The ninth in the series, which took place during June 4–6, dealt with the physical chemistry of metallic solutions and intermetallic compounds, and the tenth, on "The Mechanization of Thought Processes", during November 24–27, evoked such considerable interest that the attendance had to be limited to the two hundred who could be accommodated The proceedings of the symposium on visual problems of colour, held in September 1957 , No 19 in the series of Notes on Applied Science entitled "Signal Generators, Attenuators, Voltmeters and Ammeters at Radio-Frequencies" , and a second volume, "Tables of Everett Interpolation Coefficients", in the series of NPL-Mathematical Tables, were published during the year In addition to a full programme of lectures, talks and discussions, in which the staff have participated, there have been several sound and television programmes based on work and tests carried out at the Laboratory A transportable NPL cæsium atomic-clock was included in the exhibition "Pendulum to Atom", organized by the British Horological Institute, and the Laboratory provided items for display at the Physical Society Exhibition, the Gauge and Tool Exhibition, the Royal Society soirée, and an exhibition for freshmen at St John's College, Oxford

The Lord President of the Council, Lord Hailsham, visited the Laboratory on June 5, and the chairman of the Council for Scientific and Industrial Research, Sir Harry Jephcott, on July 17 On February 26, a sub-committee of the Select Committee on Estimates inspected the Laboratory and appeared generally satisfied with the work being done, but expressed concern at the possibility of overlap of work and facilities between the Ship Division of the Laboratory and the Admiralty in relation to research on hull and propeller design There is formal liaison between the two establishments through the Froude Ship-Research Sub-committee, and informal liaison between the superintendent of the Division and senior officials in the Admiralty

A building plan for the long-term development of the Laboratory site is being considered in consultation with the Ministry of Works, and a centre, with lecture, conference and restaurant facilities, has at long last been authorized A new physics building and a building properly equipped for the mechanical working of difficult materials have been included in the 1959–64 proposals Reference is also made to the Ship Hydrodynamics Laboratory at Feltham [which was opened by the Duke of Edinburgh on October 19, see p 926 of this issue of *Nature*]

YELLOWSTONE PARK EARTHQUAKE

ON August 18 an earthquake occurred at 06h 37m 13s G M T from an epicentre near the western boundaries of Yellowstone National Park (epicentre lat 44½° N , long 111° W) The earthquake had a magnitude of 7 1 or rather greater on the Richter Scale The shock appears to have had a normal depth of focus Most damage appears to have been caused by the earthquake near the Hebgen dam in south-western Montana The dam is built at an altitude of 6,000 ft and holds up a lake some 37 miles long in a narrow canyon, through which flows the Madison River The dam is 87 ft high and 718 ft long In addition to cracking parts of the base of the floor of the lake and producing minor cracks in the earth and rock section of the dam, the earthquake started a huge wave in the lake, which threatened further damage Fortunately, the wall held fast The surge of water in the lake and canyon is reported to have caused an air blast which stripped the clothing from one person

Some seven miles below the dam, landslides from an 8,000 ft high mountain blocked the road and the river. The road and the surrounding countryside were severely fissured. Roads leading into the western side of Yellowstone Park were closed Perhaps two hundred people, including ranchers, campers fishermen and tourists in about fifty cars, were trapped between the landslide and the lake Ten people are reported to have been killed and sixty injured Telephones and electric power installations were out of action Buildings shifted on their foundations, chimneys fell and fuel pumps toppled over

The elastic waves of the earthquake were recorded by seismographs at observatories throughout the world At Kew Observatory the provisional readings are

eP	06 hr	48 min	11 sec	G M T	
iS	06 hr	57 min	13 sec	G M T	
MH	07 hr	18 min	00 sec	G M T	amplitude 570μ
F	12 hr	00 min	00 sec	G M T	

In the past the regions most affected seismically in this part of the United States have been east of Helena, Montana (lat 46° N , long 111 2° W), and north-east of the centre of Helena (46 6° N , 112° W)

Table 1 AFTERSHOCKS OF THE YELLOWSTONE PARK EARTHQUAKE OF AUGUST 18 (ALL DURING AUGUST)

Initial day and time (G M T)				Epicentre		Magnitude Richter Scale
Day	Hour	Minute	Second	Lat (° N)	Long (° W)	M
18	07	54	32	45	111	—
18	15	26	06	44½	111	6½
19	04	04	03	45	111½	6
19	19	06	29	45	111 4	—
19	19	43	45 7	45	110½	—
19	21	45	57	45	111½	—
20	10	59	11	45	111	—
20	19	11	27	45	111	—

From the first of these epicentres earthquakes on June 27, 1925, reached intensity 10 on the Rossi-Forel Scale and caused greatest damage at Manhattan, Logan, Three Forks and Lombard From the second location shocks in October and November, 1935, attained maximum intensity 9 on the Rossi-Forel Scale However, minor shocks of intensity 4–5 (R F Scale) from an epicentre in Yellowstone National Park, Wyoming (44° N , 111° W), occurred at various times from August 24 to December 22, 1930 In 1947 (November 23) at 09h 46m 05s G M T a shallow focus earthquake from an epicentre 44¾° N , 111¾° W reached a magnitude 6¼ on the Richter Scale Earthquakes are always liable to recur at or near old epicentres

Aftershocks of the earthquake of August 1959 so far listed by the United States Coast and Geodetic Survey are given in Table 1, although smaller shocks are said to have occurred at intermediate times

E TILLOTSON

A THEORY OF AGEING

THE theory of ageing put forward by Szilard[1] refers explicitly to mammals It is the purpose of the present communication to point out that this theory cannot explain ageing in *Drosophila*, since it is inconsistent with two experimental observations This of course does not prove that it cannot explain ageing in mammals , but reasons will be given for doubting that it does so

Szilard postulates the random occurrence of 'hits', each hit rendering ineffective the genes of a whole chromosome, or perhaps of a large segment of a chromosome A cell becomes ineffective either when two homologous chromosomes have each suffered a hit, or when one of a pair of homologues has suffered a hit, and the other carries an inherited 'fault' By a fault is meant a recessive gene which in homozygous condition renders the cell inviable, or incapable of performing a necessary function in the adult organism Death occurs when some predetermined fraction of the cells initially present is in this way rendered ineffective , Szilard suggests that this fraction is of the order of 2/3 to 11/12

It is a direct consequence of this theory that, in the author's words "The main reason why some adults live shorter lives and others live longer is the difference in the number of faults they have inherited" This is the first consequence of the theory which is contradicted by observations on *Drosophila* In so far as differences in adult longevity are genetically determined, by far the largest differences are those between inbred and outbred individuals[2,3] F_1 hybrids between inbred lines live for longer than do the parental lines (sometimes for twice as long) Outbred and genetically variable wild populations have approximately the same expectation of life as do F_1 hybrids Now inbreeding increases the proportion of loci at which individuals are homozygous An individual which survives for an appreciable time as an adult cannot, by definition, be homozygous for a fault Therefore inbred individuals which survive to become adults, and which do not die immediately after emergence, are not homozygous for faults at any loci, and would be expected to be heterozygous for faults at fewer loci than are members of outbred wild populations If two inbred lines are crossed, the F_1 hybrids would be expected to carry a load of faults intermediate between the loads carried by the parental lines Thus according to Szilard's theory, inbred lines should have a higher expectation of life than wild populations, and F_1 hybrids between inbred lines should be intermediate between their parents Neither of these predictions is in fact true

Further, since males have only a single X chromosome, any hit on that chromosome in a male would render the cell inviable, whereas in a female not heterozygous for a sex-linked fault both X chromosomes must be hit before a cell becomes inviable Therefore females should live longer than males This again is not the case in *D subobscura* In some strains females do live longer than males, but in other strains, both inbred and outbred, the reverse is true This point is particularly telling since in *Drosophila* the sex chromosomes account for about one-fifth of the total chromosome material

The other group of facts which are inconsistent with the theory concern the rate of ageing at different temperatures[4] Female *D subobscura* of a particular strain have an expectation of life of about 56 days at 20° C and of 18 days at 30 5° C The changes responsible for death at 30 5° C are not repaired or reversed in individuals kept for a time at 20° C Consequently the changes responsible for death at both temperatures can properly be regarded as ageing processes If these processes were, at each temperature, those postulated by Szilard, differing only in the rate at which hits occur, it follows that individuals kept for an appreciable time at 30 5° C should have, when returned to 20° C , an expectation of life at that temperature lower than that of individuals of the same chronological age not previously exposed to 30 5° C In fact, exposure to 30 5° C for periods of the order of half the expectation of life at that temperature does not alter the further expectation of life at 20° C of males, and significantly increases that of females

Hence, if, despite the genetic evidence to the contrary, we assume that ageing at 20° C is due to random hits on chromosomes, then ageing at 30 5° C cannot be explained by the same process proceeding at a higher rate In other words, either at 20° C or at 30 5° C ageing must be due to a process different from that postulated by Szilard , it is possible, and in my view likely, that such a process is not primarily responsible for ageing at either temperature

It is perhaps unreasonable to criticize a theory intended to explain ageing in mammals by quoting observations on insects Unfortunately the temperature experiments cannot be repeated on a homoiotherm But there is some evidence[5] in mice, as well as in *Drosophila*, that inbred individuals do not live as long as outbred ones In addition to this purely observational point, there is one more general reason why Szilard's work has made a theory of ageing by somatic mutation less, and not more, promising than it had previously appeared to be It is assumed that the 'target' is a whole chromosome , a 'hit' renders ineffective all the genes carried by that chromosome This assumption is made because, as Szilard shows, if it were assumed that the target were an individual gene, it would be necessary also to assume that each individual carried a load of faults so high as to be inconsistent with the known fertility of consanguineous marriages There are events, particularly mitotic errors and chromosome breakages, which would deprive cells of whole chromosomes or of large segments of chromosomes, but they do not seem likely to be common enough to be the main cause of ageing Most biologists would be happier with a theory which assumed as the unit event a hit on a gene, using the word gene here to refer to a functional unit or cistron Perhaps the most important thing Szilard has done is to show that such a theory, at least in its simplest form, would run into difficulties

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[1] Szilard, L , *Proc U S Nat Acad Sci* , 45, 30 (1959)
[2] Clarke, J M , and Maynard Smith, J , *J Genet* , 53, 172 (1955)
[3] Maynard Smith, J , *J Genet* , 56, 227 (1959)
[4] Maynard Smith, J , *J Exp Biol* , 35, 832 (1958)
[5] Muhlbock, O , *CIBA Colloquia on Ageing*, 3, 115 (1957)

ALL the observations quoted by Mr Smith in his interesting communication relate to fruit flies and they fall into two classes observations which we may expect to be able to duplicate in the case of mammals and those which we may not Since I do not propose to discuss here whether the theory might or might not be extended to insects, I am primarily concerned with the former of the two classes

Smith states that a genetically variable, 'wild', population of fruit flies has a substantially higher life expectancy than inbred, fairly or wholly homozygous, strains derived from it He also states that the F_1 hybrid, obtained by crossing two different inbred strains, has a substantially higher life expectancy than the two inbred strains themselves Smith holds that these findings are not compatible with the theory of ageing that I proposed

It is probably true that the observations quoted above could be duplicated with mammals and I am quite prepared to accept this thesis for the sake of argument As I shall presently show, however, my theory does not preclude that the homozygous inbred strains may have a substantially smaller life expectancy than the wild type strains Further, the theory demands that the life expectancy of the F_1 hybrid be appreciably higher than that of the wild type strain, if the wild type strain carries a substantial number of faults In order to see this, we may consider the following

At present there is no evidence that a gene may be responsible for anything except for the production of a specific protein molecule which might be endowed with a specific enzymatic activity In a wild population, a given gene may be present in the form of a variety of alleles and the corresponding enzymes may differ in their turnover number For the purposes of discussion here, I shall call an allele 'weak' if the turnover number of the corresponding enzyme is small If this turnover number is very small, the allele might be a recessive lethal A completely homozygous strain is, of course, free of recessive lethals, but it may contain a number of 'weak' alleles

Again, for the purposes of discussion here, I shall adopt a somewhat over-simplified picture, and shall disregard the possibility that the enzyme-levels in the somatic cells may be determined to some extent by the regulatory mechanisms of the cell through enzyme induction or otherwise On this over-simplified basis, we may then say that the somatic cells of an inbred strain, which is homozygous for a number of 'weak' alleles, are impoverished in the corresponding enzymes, so far as their biochemical activity is concerned

My theory assumes that only a small fraction of the enzymes, less than one-fifth perhaps, is important for the functioning of the somatic cells of the adult, while practically all of the enzymes may be important for differentiation and morphogenesis during the embryonic life of the individual Accordingly, we may then expect that an individual of the inbred strain (which is homozygous for a number of 'weak' alleles) may be maldeveloped, in the sense that it may have a much smaller reserve at birth than the wild type individual, with respect to a number of physiological functions Thus it is conceivable that an individual belonging to an inbred strain may die at an age at which f, the 'surviving' fraction of its somatic cells, has fallen to, say, $f^* = \frac{1}{2\ 72} \approx \frac{1}{e}$, whereas an individual belonging to the wild-type strain may die at an age at which f, the 'surviving' fraction of its somatic cells, has fallen to about $f^* = \frac{1}{7\ 4} \approx \frac{1}{e^2}$

We may compute for this case the most probable age at death, for man, from formula (14) given on p 33 of my paper (*loc cit*) which reads

$$x_r + r = \sqrt{4m\ln\frac{1}{f^*}} + \ln\frac{1}{f^*}$$

where x_r is the number of hits at death , r is the number of the inherited faults , $m = 23$ is the number of chromosome pairs and f^* is the surviving fraction of the somatic cells at the age of death

The most probable age at death, t_r, is given by $t_r = 6 \times x_r$ years

For the inbred strain we obtain t_r, the most probable age at death, by writing $r = 0$ and $\ln\frac{1}{f^*} \approx 1$ We thus obtain $t_r = 63\ 6$ years

For the wild type we obtain t_r, the most probable age at death, by writing $r = 2$ and $\ln\frac{1}{f^*} \approx 2$ We thus obtain $t_r = 81\ 5$ years The actual value for white females in the United States is $t_r = 80\ 5$ years

For the F_1 hybrid we obtain t_r, the most probable age at death, by writing $r = 0$ and $\ln\frac{1}{f^*} \approx 2$ We thus obtain $t_r = 93\ 5$ years This is 12 years more than the value for the wild type

It may thus be seen that a substantially shortened life expectancy of the homozygous, inbred strain, as compared with the wild type, need not be inconsistent with the theory. However, an increased life expectancy of the F_1 hybrid as compared with the wild type strain is a necessary consequence of the theory.

This consequence of the theory could be tested by experiments on short-lived mammals, say mice. In order to render the experiment more sensitive, one may first expose to ionizing radiation a population of wild type mice over several generations and may thereby increase the number of faults in the population. Starting with such a 'wild' population, enriched in faults, one would then select two unrelated families and derive from them two inbred homozygous strains. The theory demands that the F_1 hybrid of these two inbred strains should live appreciably longer than the population from which the two families were selected. Given a suitable opportunity, I propose to arrange for experiments of this sort. A negative result might well prove fatal for the theory.

I should perhaps add at this point that the observed differences in the life expectancy of the male and the female do not provide a usable criterion for the validity of the theory because f^*, the 'surviving' fraction of the somatic cells at death, might differ appreciably for the male and the female.

Smith cites a rather peculiar effect of the temperature on the life expectancy of the male and the female in *D. subobscura*. It seems to me that any future theory of ageing that may be generally applicable to insects would be put to an unduly severe test, were one to demand that it account for this particular effect.

Because the theory of ageing that I proposed makes quantitative predictions, it is capable of being disproved by experiments and, sooner or later, such might be its fate. At present I am not aware, however, of any valid observations which contradict this theory. In these circumstances, I am not at present disposed to agree with the appraisal of the theory implied in the last paragraph of Mr. Smith's communication.

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CROSS-LINKING OF DEOXYRIBONUCLEIC ACID IN SPERM HEADS BY IONIZING RADIATIONS

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IRRADIATION with X-rays of deoxyribonucleic acid in dilute aqueous solution leads to a reduction in the size of the molecule due to attack by hydroxyl radicals[1]. Irradiation of the solid acid as the sodium salt was claimed by us to reduce the molecular weight[2] and we wrongly concluded (see below) that ionizing radiations, whether acting directly or indirectly via free radicals from water, produce breaks in the main chain. Since *in vivo* deoxyribonucleic acid is conjugated with protein, nucleoprotein obtained from the sperm of fish was irradiated and attempts were made to isolate the deoxyribonucleic acid so as to measure its molecular weight and to see if its radiosensitivity was affected by the presence of proteins. Sperm heads were chosen for these experiments since they contain essentially only deoxyribonucleic acid and protamine. They can be prepared without denaturation as they take up only a few per cent of water and no break up of the native configuration occurs due to swelling. After the nucleoprotein complex has been dissociated in 2 *M* sodium chloride, deoxyribonucleic acid can be isolated in a very pure form (less than 0.1 per cent of protein contamination) by precipitating the protamine by the usual procedure[3] with an anionic soap, sodium dodecyl sulphate. The detergent–protamine complex is removed by centrifugation at 20,000*g* for 30 min. If the sperm heads are obtained from viable sperm by cytolysis at temperatures below 4° C., the recovery of deoxyribonucleic acid is quantitative (better than 95 per cent).

Following irradiation by 20,000–1,000,000 rads with 1-MeV. electrons from a Van de Graaff machine, the sperm heads dissolved apparently completely in 2 *M* sodium chloride, but after the removal of the protamine complex it was found that a substantial fraction of the deoxyribonucleic acid had been lost. In this dose range, no deoxyribonucleic acid was lost if the solution in 2 *M* sodium chloride was centrifuged at 20,000*g* for 2 hr. It was found that the loss of deoxyribonucleic acid was related to the dose as shown in Fig. 1. No significant difference was found between sperm-heads from salmon, trout and herring, and moreover, the same effect was obtained if viable whole sperm were irradiated in their seminal fluid and the nucleoprotein isolated after irradiation.

Evidence for Cross-linking

A possible reason for the loss of deoxyribonucleic acid on the addition of the detergent is that some of the protamine is chemically linked by the radiation to the deoxyribonucleic acid so that it, too, is involved in the detergent-complex[4]. But all attempts to demonstrate such a combination have failed. Thus the deoxyribonucleic acid was precipitated quantitatively from the dispersion of sperm heads in 2 *M* sodium chloride by the addition of a polyvalent cation, lanthanum chloride, and the precipitate analysed for protein by paper chromatography. No differences could be detected between the control and irradiated samples though the latter 'lost' 30–50 per cent of their deoxyribonucleic acid on the addition of the detergent and neither contained more than 0.5 per cent protein. The best evidence that there was no combination with protein was obtained by isolating the deoxyribonucleic acid by ultracentrifugation. In a preparative 'Spinco' the deoxyribonucleic acid from a solution of sperm heads in 2 *M* salt (concentration of deoxyribonucleic acid 0.03 per cent)

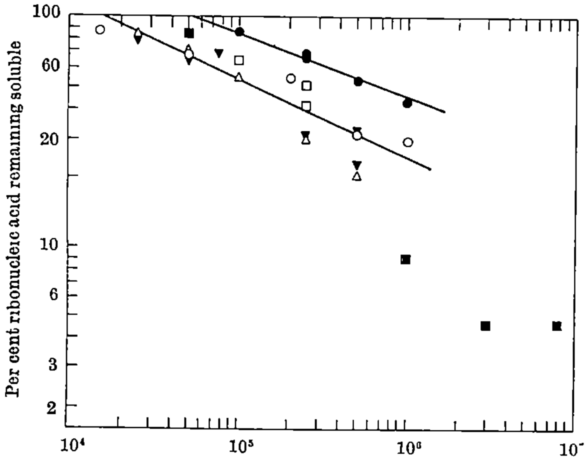

Fig 1 Effect of 1 2-MeV electrons on the recovery of soluble deoxyribonucleic acid from nucleoproteins -■- and -□-, Different preparations of salmon sperm heads, -○-, trout sperm heads, -▼-, nuclei from herring testes, -△-, viable trout sperm, -●-, 'reconstituted' nucleoprotamine fibres from trout sperm heads

was completely spun down after 15 hr at 35,000*g* The pellet of deoxyribonucleic acid was dissolved in water and then respun in 2 *M* salt under the same conditions This was repeated twice and the final pellet of deoxyribonucleic acid contained less than 0 1 per cent protein, according to the sensitive chromatographic technique of analysis developed by Kirby[5] No difference in the protein content could be detected between deoxyribonucleic acid prepared in this way from irradiated and unirradiated sperm

However, the solubility behaviour of the pellets of deoxyribonucleic acid obtained by ultracentrifugation is changed by irradiation and this provides evidence for the mechanism by which part of the deoxyribonucleic acid is removed by soaping after irradiation While the control samples dispersed completely in 0 1 *M* sodium chloride, the deoxyribonucleic acid pellet from irradiated sperm heads contained some deoxyribonucleic acid in gel form which could be removed by spinning at 20,000*g* for 3 hr The amount of deoxyribonucleic acid spun out under these conditions increases with radiation dose and is, within experimental error, equal to the soaping loss This gel component separated from irradiated sperm heads by centrifugation is not made soluble by the addition of trypsin, which digests protamine very rapidly

These results can be interpreted as showing that on irradiation some of the deoxyribonucleic acid has been cross-linked to form a very loose gel-like network which is so highly swollen in water that it is not spun out in a short time by centrifugation at 20,000*g* but is scavenged by the very flocculent precipitate produced by the addition of sodium dodecyl sulphate to 2 *M* sodium chloride After very high-speed centrifugation this material is compacted and can be removed by ordinary centrifugation at 20,000*g* Irreversible behaviour of this type is to be expected from very lightly cross-linked gels This interpretation is further supported by the fact that after very large doses (that is, greater than 3 × 10^6 rads), deoxyribonucleic acid gel is removed by centrifugation at 20,000*g* presumably because the swelling has been reduced by additional cross-links which tighten up the network After 8 × 10^6 rads the sperm heads no longer disperse at all in concentrated salt solutions

The relationship between the amount of deoxyribonucleic acid removed by soaping (that is, the amount not behaving as gel) and radiation dose (see Fig 1) is that found for cross-linking of synthetic polymers[6] The threshold, known as the gel point, arises from the fact that a minimum number of cross-links have to be formed before any part of the material has been linked into an 'infinite' network required for it to behave as a gel Charlesby[6] demonstrated theoretically for linear polymers that at the gel point the number of cross-links equals the number of molecules present Since the cross-links are distributed statistically, some molecules will be unchanged whereas others will be involved in several cross-links, and it is these which form the gel fraction

From the simple relationship of Charlesby it is possible to calculate the energy that has to be put into the system for a cross-link to be produced from the threshold dose and the molecular weight of the polymer The weight average molecular weight of the deoxyribonucleic acid was measured by light scattering and found to be between 9 and 11 × 10^6, though there was some variation from sample to sample These high molecular weights, which are confirmed by viscosity measurements, can only be obtained by starting the preparation with viable sperm If the sperm heads are stored, deoxyribonucleic acid of lower molecular weight is obtained With a threshold of 2 × 10^4 rads and deoxyribonucleic acid having a weight average molecular weight of 10^7 (assumed to be twice the number average) a value of 40 eV per cross-link formed is obtained This shows that the cross-linking reaction is a very efficient process

From the shape of the curve relating radiation dose and gel formed, it is possible[6] in polymer systems to determine whether some breaking of chains occurred at the same time as cross-linking For this calculation the points at high doses are critical, at the same time, experimentally these are the least reliable, because they are biased by trapping non-cross-linked material within the gel network If applicable, this calculation would show that there cannot be more than one break for every four cross-links, but that there may be less The average molecular weight of the residual deoxyribonucleic acid left after the removal of gel by centrifugation at 20,000*g* is less than that of the starting material and continues to decrease with increasing dose This is in accord with cross-linking theory[6] since the deoxyribonucleic acid is polydisperse and the largest molecules will be the first to enter the gel fraction, the smaller molecules are left in the soluble fraction This drop in the average molecular weight does not imply the occurrence of chain scission

Mechanism of Cross-linking

No analytical work has been attempted to determine the nature of the cross-link that is formed between deoxyribonucleic acid molecules The possibility that they are an effect of aggregation by secondary valency forces (for example, hydrogen bonds) has been considered, but seems very unlikely in view of the general properties of the gel and the fact that it is not dispersed by the powerful hydrogen-bond breaking solvent, 4 *M* urea We do not know whether the gel-like structure is formed by molecules that are joined together by a covalent bond or by a chain-branching mechanism, involving breakage and reunion, which is called end-linking by Charlesby At the present time we use the term cross-linking loosely to denote a reaction that results in the formation of deoxyribonucleic acid with gel-like properties

A degree of order seems to be necessary for efficient cross-linking since the dose of radiation needed to produce gel in reconstituted nucleoprotamine fibres, which were obtained by diluting solutions of sperm heads in 2 *M* sodium chloride, is three times greater than that needed to gel the sperm heads, which have the same overall composition The reconstituted product is known to have an irregular structure and its composition is not stoichiometric[7] In recent experiments with Mr John Lett, evidence for cross-linking has been found even when pure deoxyribonucleic acid is irradiated as a solid Although no gel is formed, except at very high doses, the results suggest that both cross-linking and main-chain breaking occur simultaneously, but that the efficiency of the former depends very much on the nature of the sample The great preponderance of main-chain breaks found in our earlier work[2] may probably be ascribed to the fact that the deoxyribonucleic acid used was of lower quality The fact that our present samples have nearly twice the molecular weight of those used earlier supports this explanation The exact factors determining the change-over from cross-linking to degradation when the sodium salt of deoxyribonucleic acid is irradiated are now being studied, but it seems that the amount of cross-linking is very dependent upon the closeness of the packing of the deoxyribonucleic acid chains The cross-linking is due to the direct action of the radiation , the free radicals produced in the water in which the sperm heads are suspended play no part, presumably because their range is too short This was established by the fact that the cross-linking efficiency is independent of the amount of water in which the specimens are suspended and, moreover, alcohol-dried herring sperm give essentially the same result, though for experimental convenience we have preferred to irradiate suspensions

The addition of 1 per cent cysteamine to a 10 per cent suspension of sperm heads provides powerful protection, reducing the amount of cross-linking to approximately half This is not in conflict with the deduction that the action is largely direct, since protection under these conditions was first reported by Alexander and Charlesby[8] for polymers and more recently by Markovich[9] for phage If the irradiations are carried out under oxygen instead of air the amount of gel-like nucleic acid that is formed is greatly reduced The importance of packing may arise from the fact that oxygen combines with the radiation-produced reactive centre and thereby prevents it from giving a cross-link Competition by oxygen may explain why in preliminary experiments we have failed to find gel-like deoxyribonucleic acid in the nuclei of irradiated chicken erythrocytes in which the nucleoprotein is much less closely packed than in sperm heads

Biological Implications

The production of a cross-link by radiation provides a very effective way whereby one event can destroy the biological integrity of a macromolecule Even if the part of the molecule involved in the formation of the cross-link is not essential to activity, the joining of two molecules together will change the physical characteristics of the molecule profoundly Since a dose of 1,000 rads produces a cross-link in, approximately, 5 per cent of the deoxyribonucleic acid molecules present in the sperm cell, quantitatively this reaction is capable of explaining cellular effects of radiation which require doses of this order of magnitude Such a theory would appear all the more attractive since one of the predominant chemical changes produced by the radiomimetic substances such as nitrogen mustards is the cross-linking of deoxyribonucleic acid in the cell nucleus[10] The similarity of the end effects produced by radiation and the chemicals would then follow from the similarity of the chemical lesion Against this mechanism is the fact that densely ionizing radiation such as polonium α-rays and 2-MeV neutrons are about ten times less efficient in cross-linking the deoxyribonucleic acid in sperm heads than are the sparsely ionizing radiations of X-, γ- and β-rays Yet the densely ionizing radiations are much the more effective in causing delay of mitosis and cell death—*a priori* one would expect that the chemical reaction which initiates the sequence of events leading to cellular effects must also be more readily produced by the densely ionizing radiations The possibility remains that there is a qualitative difference between sparsely and densely ionizing radiations in their effect on deoxyribonucleic acid, and the very low cross-linking efficiency of the α-rays could best be explained by the simultaneous production of a nearly equal number of main-chain breaks

For the inactivation of viruses the relative effectiveness of the different radiations is in the reverse order from that found for cellular effects and in qualitative agreement with the cross-linking reaction Since the tightness of the packing of deoxyribonucleic acid appears to facilitate the formation of cross-links, it is possible that this is the reaction responsible for the inactivation of bacteriophage by ionizing radiation

We wish to thank Mr D Moore, of the Experimental Radiopathology Unit of the Medical Research Council, Hammersmith Hospital, London, W 12, for his unfailing helpfulness in irradiating our samples, and Mrs A Szwarcbort and Mr P Kopp for their technical assistance This investigation has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research Royal Cancer Hospital) from the British Empire Cancer Campaign, and Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U S Public Health Service

[1] Taylor, B , Greenstein, J P , and Hollaender, A E , *Arch Biochem Biophys* , **16** 19 (1948) Butler, J A V , and Conway, B E , *J Chem Soc* ,3418 (1950) Daniels, M , Scholes, G , and Weiss, J , *Nature*, **171**, 1153 (1953)

[2] Alexander, P , and Stacey, K A , "Progress in Radiobiology", 105 (Proc Fourth Int Conf Radiobiology, 1955) (Oliver and Boyd, 1956)

[3] Kay, E R H , Simmons, N S , and Dounce, A L , *J Amer Chem Soc* , **74**, 1724 (1952)

[4] Alexander, P , and Stacey, K A , *Radiation Res* , **9**, 85 (1958)

[5] Kirby, K S , *Biochem J* , **66**, 495 (1957)

[6] Charlesby, A , *Proc Roy Soc* , A, **222**, 60 (1954)

[7] Alexander, P , *Biochim Biophys Acta*, **10**, 595 (1953)

[8] Alexander, P , and Charlesby, A , *Nature*, **173**, 578 (1954)

[9] Markovich, H , *Radiation Res* , 9, 149 (1958)

[10] Alexander, P , Cousens, S F , and Stacey, K A , in Ciba Symp on "Dry Resistance in Micro-organisms," 294 (Churchill, London, 1957) Alexander, P , and Stacey, K A , *Acta Union contra Cancrum* (in the press) , *Biochem Pharmacology* (in the press)

CARBONIC ANHYDRASE IN THE DECIDUOMA OF THE RAT

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ALTHOUGH extensive investigations have been made of various enzymes in placental tissue, latively little attention has been paid to the nzymes of the experimentally induced decidual ssue, that is, the deciduoma

Deciduomata offer an excellent opportunity for search on the maternal components of the placenta, pecially during the earliest phases of development, nd also in embryo-free uteri Nevertheless, the nly enzyme studied hitherto in detail in deciduoatous tissue is the histaminase[1], which has been emonstrated as characteristic of the maternal ortion in the placenta of man, rabbit and rat The esence of certain other enzymes in the deciduoma as indicated but results were only reported in mmary[2]

Carbonic anhydrase is another typical placental zyme[3] Its presence was first detected in the ammalian female reproductive tract in the endoetrium of the progravid rabbit[4] Investigations of s distribution showed that although the occurrence carbonic anhydrase in the endometrial mucosa is nited to relatively few species, it is invariably sociated with the placenta of mammals, it has en located in the maternal portion of the placenta large domestic animals, carnivores, laboratory dents and insectivores[5]

Since experimentally induced deciduomata are ucturally and functionally analogous to the cidual portion of the placenta proper, it was of terest to examine the induced decidual tissue for rbonic anhydrase For several reasons the rat erus is specially suitable for such a study The endometrium contains negligible amounts of rbonic anhydrase during œstrus, and the content this enzyme does not increase in response to ogesterone treatment[3] This is in contrast to the bbit endometrium where the response to progestere, as expressed by an increased content of carbonic hydrase, is so spectacularly characteristic that it ms the basis of an assay for luteoid potency[6] ice the rat does not show a comparable progestere-conditioned rise in carbonic anhydrase content, y increase in enzyme content found as the result inducing decidualization can be safely ascribed the presence of deciduomatous tissue Furtherre, recent studies[7–11] offer various techniques for uction as well as suppression of deciduoma in rat

This investigation was carried out to determine ether carbonic anhydrase is present in the decioma of the rat, if so, how early in the development the deciduoma the enzyme becomes detectable, ether the enzyme activity, if present, is dependent on the method of deciduoma induction, and finally, whether the suppression of the development by histamine antagonism, or by disturbance of the hormonal equilibrium, is reflected by the level of carbonic anhydrase activity

The enzyme-assay technique was essentially the same as described earlier[3] No attempt was made to dissect the deciduoma from the uterine wall, the results were expressed as enzyme units (E U) per gram entire uterine horn, fresh-weight Pseudopregnancy was induced in 3–4 months old female albino rats with regular œstrus cycles (stock colony, Anatomy Department, University of Birmingham), by faradic stimulation of the cervix on days of pro-œstrus and œstrus, of the cycle On the fourth day of leucocytic vaginal smears certain procedures were applied in order to induce or to suppress deciduoma formation

Four series of experimental animals were set up Series I consisted of 20 females injected intraperitoneally with 20 mgm pyrathiazine ('Pyrrolazote', Upjohn), to evoke the decidual response by systemic means[10] In series II there were 15 females which were laparotomized under ether anaesthesia on the fourth day of pseudopregnancy, the antimesometrial wall of the uterine lumen was scratched along its length with a burred needle to produce in these animals the typical deciduoma induced by trauma Series III included 10 females, laparotomized as above, the endometrium in both uterine horns was traumatized, but the lumen of one horn in each rat was instilled with 0 1 ml of saline solution containing 1 mgm of the anti-histaminic, diphenhydramine hydrochloride, to suppress the decidual development Series IV consisted of 10 females which were given intraperitoneally 20 mgm pyrathiazine, this being followed immediately by a subcutaneous injection of 1 mgm 'ergotoxine complex' (made up of ergocristine, ergocornine and ergocryptine methanesulphonate, 1 1 1, in 50 per cent ethanol), which has been previously shown[7,9] to prevent the formation of deciduoma by disturbing the hormonal balance In all four series the uterine weights were recorded, and the horns used for enzyme assay, at 24, 48, 72 or 120 hr, respectively, after the termination of the procedure provoking deciduoma, groups of 4 animals being used at each stage in series I, 3 in series II, and 2 each in series III and IV

It was found that carbonic anhydrase is undoubtedly present in the rat deciduoma The values established were low (ranging from 2 to 12 E U /gm) as compared with the progestational endometrium of the rabbit (up to 100 E U /gm), but they were of the same order as those obtained for the rat maternal placenta (10 E U /gm)

The findings relating to the different experimental techniques used for induction (series I and II) and suppression (series III and IV), respectively, of the decidual reaction can be summarized as follows.

Josiah Macy Fellow 1957–58, on leave at the Department of tomy, University of Birmingham

Sir Simon Marks Fellow, and University Research Fellow, 1957–58, eave at the Department of Anatomy, University of Birmingham

Carbonic anhydrase activity in the deciduoma appeared irrespective of the type of inducing agent The presence of the enzyme was evident already at 24 hr after induction, and it was still demonstrable in deciduomata 120 hr old When the decidual response was suppressed, whether by local application of an antihistaminic drug, or alternatively by interference with the hormonal equilibrium, as in the rats treated with ergotoxin, no measurable carbonic anhydrase activity was detected in the uteri

Early cellular evidence of decidualization appears as increased diploid activity, this can be demonstrated about 18–20 hr after stimulation[8] Other, probably even earlier, signs of response include changes in uterine vascularity The appearance of carbonic anhydrase is therefore consistent with the morphological signs of onset of the decidual development It is at present difficult to account for the fact that whereas there is a remarkable shift in decidual weight, from less than 5 per cent of the uterine mass to 6–7 times the initial weight of the whole uterus, yet the concentration of carbonic anhydrase, in terms of E U /gm uterine horn, remains fairly constant throughout the 120 hr of the experimental period However, it is probable that further analysis of a larger number of specimens and over a more extended period, preferably coupled with a histochemical identification of the cellular elements responsible for carbonic anhydrase activity, would help to resolve this problem

[1] Ahlmark, A , *Acta Physiol Scand* , **9**, Supp 28 (1944) Swanberg, H , *ibid* , **23**, Supp 79 (1950) Roberts, M , and Robson, J M , *J Physiol* , **119**, 286 (1953)

[2] Meyer, R K , "Ciba Colloquia Endocrinol ", **1**, 266 (1952)

[3] Lutwak-Mann, C , *J Endocrinol* , **13**, 26 (1955)

[4] Lutwak-Mann, C , and Laser, H , *Nature*, **173**, 268 (1954)

[5] Lutwak-Mann, C , *Boll Soc Ital Biol Speriment* , **32**, 611 (1956)

[6] Lutwak-Mann, C , and Adams, C E , *J Endocrinol* , **15**, 43 (1957), *Acta Endocrinol* , **25**, 405 (1957)

[7] Shelesnyak, M C , *Amer J Physiol* , **179**, 301 (1954)

[8] Sachs, L , and Shelesnyak, M C , *J Endocrinol* , **12**, 146 (1955)

[9] Shelesnyak, M C , "Rec Prog Hormone Res ", **13**, 269 (1957)

[10] Kraicer, P F , and Shelesnyak, M C , *J Endocrinol* , **17**, 324 (1958)

[11] Shelesnyak, M C , *Mem Soc Endocrinol* , **6**, 84 (1959)

TRANSMISSION OF A VIRUS TO STRAWBERRY PLANTS BY A NEMATODE (*XIPHINEMA* sp.)

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LISTER in 1958[1] described symptoms shown by diseased strawberry plants (var Cambridge Favourite) which he found to be infected with the raspberry yellow dwarf virus* of Harrison[2] These symptoms closely resembled those of a virus disease reported earlier that year at East Malling[3] affecting a range of cultivated strawberry varieties (including Cambridge Favourite) known to be tolerant to the usual (aphid-borne) crinkle virus complex, and tentatively referred to as yellow crinkle

In subsequent work at East Malling under a Colombo Plan Fellowship (A J) the causal virus of yellow crinkle and of mosaic[4] was transmitted by mechanical inoculation from plants of a number of stolons from the 'healthy' plants in the inoculated strawberry varieties, including Cambridge Favourite, to a wide range of herbaceous plants, including *Petunia hybrida* Vilm and *Chenopodium amaranticolor* Coste and Reyn One of these isolates, in *Petunia hybrida*, derived from a Cambridge Favourite strawberry plant showing typical symptoms, was successfully transmitted back to healthy plants of the same variety by mechanical inoculation Finally, cross-protection and serological tests of these isolates with authentic raspberry yellow dwarf virus and antiserum (supplied by the Scottish Horticultural Research Institute) indicated a close relationship with the latter virus

Soil transmissibility was confirmed experimentally when healthy plants of Cambridge Favourite strawberry and *Petunia hybrida* were potted in soil collected from contiguous strawberry plantations (*a*) known to be infected with yellow crinkle and (*b*) free from any symptoms of such infection Plants grown in the former afterwards developed symptoms, whereas those in the latter remained apparently healthy

In view of the conclusion of Hewitt *et al* [5] that a nematode, *Xiphinema index*, was a vector of the soil-borne fan-leaf disease of grape vines in California, samples of soil from the diseased and from the healthy strawberry plantation sources indicated as (*a*) and (*b*) above were compared for their nematode content with a Seinhorst elutriator In addition to certain species commonly found in Great Britain and present in both soils, a species of *Xiphinema* (originally determined as *X index*[6] but now known to be an undescribed species) was identified but only from the soil of the plantation infected with raspberry yellow dwarf virus The results of two experiments on the role of this nematode in the transmission of this virus to strawberry follow

In these experiments healthy Cambridge Favourite strawberry plants were grown in nematode-free soil in pots situated in an insect-proof glasshouse, the control and inoculated series being isolated from each other in adjacent compartments In the first experiment a healthy and an infected plant were established (with intermingled roots) in each pot, whereas in the second no infected plants were used

As it was thought that soil texture might have some effect on the survival of the nematodes to be added, the soil used throughout both these experiments was collected from the plantation of apparently healthy strawberry plants, that is, (*b*) above Healthy Cambridge Favourite strawberry plants grown in this soil prior to heating it remained healthy Samples of this soil were then maintained at approximately 60° C for ½, 1 and 1½ hr , respectively, to kill all nematodes present, and subsequent examinations for nematodes after three days, and again after three weeks, of storage at laboratory temperature showed that none had survived these treatments. Soil for the experiments was therefore uniformly preheated for 1 hr. at 60° C. approx.

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* Now known to be the same as *Arabis* mosaic virus Markham and Smith

For the first experiment the nematodes were extracted, on two occasions, from the soil of the infected strawberry plantation, (*a*) above, and fifty *Xiphinema* hand-picked from each extraction were added in water suspension to the soil in each pot in the 'inoculated' series, making 100 nematodes per pot in all. For the second experiment 100 nematodes from the same source were similarly added to each pot, but on one occasion only. No nematodes were added to the 'control' pots in either experiment. A stolon from each of the strawberry plants (infected and healthy) was rooted during the course of the experiments into steam-sterilized standard greenhouse compost in adjacent pots, and acted as a supplementary indicator of infection.

Both experiments were set up in the winter of 1958–59, starting in October, and from about eight months afterwards, that is, in the summer of 1959, yellow crinkle symptoms developed on certain of the stolons from the 'healthy' plants in the inoculated series and later on the parent plants themselves. Confirmatory tests were made from each plant in both experiments by mechanical inoculation to indicator plants of *Chenopodium amaranticolor* and *Petunia hybrida*, irrespective of whether that strawberry plant had itself developed symptoms. These tests of the control plants in both experiments have all yielded negative results.

Table 1

Treatments	Exp. 1 With infector plants		Exp. 2 Without infector plants	
	No. of test plants	No. of test plants infected	No. of test plants	No. of test plants infected
Soil inoculated with *Xiphinema* sp.	13	5	10	4
Control	9	Nil	5	Nil

From the results of these two experiments, summarized in Table 1, it is concluded that the presence of the added nematodes in the soil was an essential factor in the subsequent transmissions of the raspberry yellow dwarf virus to the healthy strawberry plants. The full details of this and associated research bearing on this subject are in course of preparation.

We are indebted to Dr. R. S. Pitcher of this Station for the identification of the nematodes.

[1] Lister, R. M., *Plant Path.*, 7, 92 (1958).

[2] Harrison, B. D., *Ann. App. Biol.*, **46**, 221 (1958).

[3] Rep. E. Malling Res. Sta. for 1957, 25 (1958).

[4] Posnette, A. F., Rep. E. Malling Res. Sta. for 1955, 120 (1956).

[5] Hewitt, W. B., Raski, D. J., and Goheen, A. C., *Phytopath.*, **48**, 586 (1958).

[6] Rep. E. Malling Res. Sta. for 1958, 33 (1959).

MACROMOLECULAR COMPONENTS OF *CHLORELLA PYRENOIDOSA*

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SUBCELLULAR organelles from disrupted cells of mammalian tissues, bacteria, yeast, blue-green algae and the seedlings of pea plants have been characterized in the ultracentrifuge[1,2]. There appears to be no report on the characterization of organelles isolated from green algae. In connexion with an exploratory study by chemical means of the various nucleic acid and protein containing fractions of *Chlorella pyrenoidosa*[3], we examined the ultracentrifuge patterns obtained from actively photosynthesizing algal cells as well as from the cells of a chlorophyll-less mutant (No. *G* 11; this mutant strain was kindly sent to us by Dr. Mary Belle Allen, Kaiser Foundation Research Institute, Richmond, California), both of which we cultured on complete and on nitrogen-free media. Use of the chlorophyll-less mutant permitted us to assess the effect of loss of photosynthetic ability on the macromolecular organization of the cell. We were interested in nitrogen deficiency because of the shift in synthetic effort in nitrogen-deficient *Chlorella* from protein to fat synthesis[4], because it had been shown that nitrogen starvation in *Torula* and *Pseudomonas* produced a much greater decrease in the cellular content of nucleic acid than of protein[5], and because the 40 *S* organelles of *E. coli* were found to break down within 2 hr. after the bacterium was transferred to a nitrogen-free medium[6].

Chlorella pyrenoidosa was cultured on a modified Bristol's solution[7] of inorganic salts in air enriched with carbon dioxide. The medium for the chlorophyll-less mutant was supplemented with 1 per cent glucose. Nitrogen deficiency was produced by transferring logarithmically growing cells to the same medium minus the nitrogen (as potassium nitrate) for a 3–6-day period. The algae were harvested from the cultures by centrifugation at 3,000*g* and were washed once with a buffer (0·005 *M* magnesium sulphate, 0·005 *M* potassium dihydrogen phosphate/dipotassium hydrogen phosphate, *p*H 7·0). The paste of cells was ground for 30 min. with 4–6 times its weight of 'Carborundum' in a cold mortar and pestle. With 600-mesh 'Carborundum' 40–60 per cent of the cells were broken. Additional operations were also carried out in the cold. The 'Carborundum' was separated at 130*g* and washed four times with buffer. Intact cells, chloroplasts and large particulates were sedimented from the combined washes at 30,000*g* for 15 min. The 30,000*g* supernatant solutions were spun for 1–4 hr. at 130,400*g*, and the resulting pellets were resuspended overnight in buffer and examined in a 'Spinco' Model *E* analytical ultracentrifuge at 4–6° C.

A typical ultracentrifuge pattern from actively growing and photosynthesizing cells is shown in Fig. 1*a*. As with the pea seedling epicotyls[2], the major component has a sedimentation coefficient of

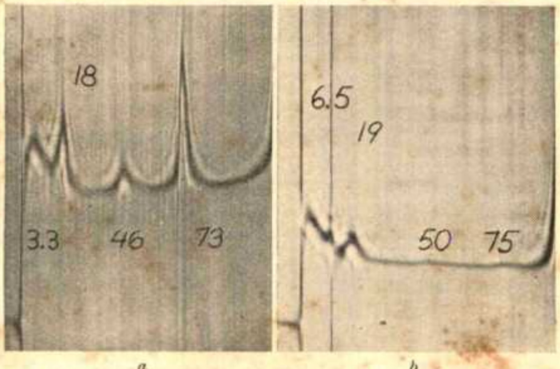

Fig. 1. Ultracentrifuge patterns of macromolecular constituents of photosynthesizing *Chlorella pyrenoidosa*. Numbers on peaks are sedimentation coefficients corrected to water at 20° C. *a*, 2-hr. 130,400*g* pellet from 4·4 gm. of normally growing cells, after 8 min. at 59,780 r.p.m., bar angle of 40°; *b*, 2-hr. 130,400*g* pellet from 5·6 gm. of 3-day nitrogen-starved cells, after 20 min. at 42,040 r.p.m., bar angle of 40°

75 *S*. The next slower peak, of sedimentation coefficient 46–50 *S*, probably corresponds to the 58 *S* dissociation product of the 75 *S* pea seedling particle. Only in preparations from stationary phase algal cultures, or when 'Carborundum' of grit smaller than 320 mesh was used as the grinding agent, did we observe another peak, 32–36 *S*, which may correspond to the second (38 *S*) dissociation product which Ts'o *et al.*[1,8,9] found in the pea seedlings. The 18–20 *S* component appears to be the Fraction I protein which has been found in the extracts of all green plants[10,11]. The 3·3 *S* component corresponds to a protein fraction that has been observed in various microbes[2]. Small amounts of a 105–110 *S* peak, though not evident in Fig. 1*a*, were observed in our preparations from time to time. This appears to be analogous to the 105 *S* peak in the pea epicotyl preparations[1,8].

Although the 75 *S* and 46–50 *S* components were degraded when incubated overnight in the cold with pancreatic ribonuclease in the magnesium sulphate/phosphate buffer, they were unaffected by pancreatic deoxyribonuclease. Overnight treatment with trypsin in the cold also largely degraded the 75 *S* organelles. In 0·01 *M* tris/0·005 *M* magnesium sulphate buffer, at *p*H 8·0, the 75 *S* component was stable for at least 3 days in the cold, but was completely degraded at the end of 5 days. In 0·01 *M* sodium ethylenediamine tetraacetate, at *p*H 7·0, it was completely degraded after 7 hr. at room temperature. These properties are similar to those of the pea seedling[9] and yeast[12] 75 *S* organelles.

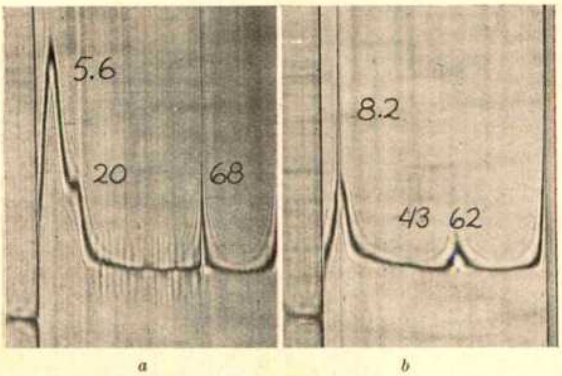

Fig. 2. Ultracentrifuge patterns of macromolecular constituents of chlorophyll-less *Chlorella pyrenoidosa*, strain *G* 11. Numbers on peaks are sedimentation coefficients corrected to water at 20° C. *a*, 2-hr. 130,400*g* pellet from 5·5 gm. of normally growing cells, after 22 min. at 42,040 r.p.m., bar angle of 50°; *b*, 2-hr. 130,400*g* pellet from 6·6 gm. of 3-day nitrogen-starved cells, after 18 min. at 42,040 r.p.m., bar angle of 50°.

The high concentration of the slowly sedimenting component (5·6–9·2 *S*) in preparations from the chlorophyll-less mutant cells (Fig. 2) is the most striking difference from the normal photosynthesizing cell preparations. In this respect the ultracentrifuge patterns of the mutant cell preparations resemble those obtained from yeast[1] and *E. coli*[2], which also require an organic source of carbon, like glucose, in their growth media.

Although Dagley and Sykes[6] found that the 40 *S* organelles of *E. coli* disappeared almost completely after the bacteria were incubated for 2 hr. on a nitrogen-free medium, Wolfe[13] and Ashikawa[1] detected appreciable quantities of 80 *S* organelles in preparations from yeast even after two days of nitrogen starvation. We could detect no significant decrease in the relative amount of the 75 *S* organelle from *Chlorella* after 24 hr. of nitrogen starvation, but after three days the size of the peak was drastically reduced (Figs. 1*b* and 2*b*). Marked reductions were also observed in the sizes of the other protein-containing peaks. On a dry-weight or per cell basis, three-day nitrogen-deficient cells contain only one-half as much nucleic acid and three-fourths as much protein as do normally growing cells; and the base composition of the residual nucleic acid differs considerably from that of the normal cells[3]. Since the greatest loss of nucleic acid is from the centrifugal fraction (1 hr. at 130,400*g*) that is primarily composed of the 75 *S* component in normally growing cells, it appears that loss of this component from the ultracentrifuge patterns in nitrogen-starved cells represents an actual loss of the functional 75 *S* organelles to the cells.

The sharp, slowly sedimenting (5·6–8·2 *S*) spike in the ultracentrifuge patterns of the nitrogen-deficient cells (Figs. 1*b* and 2*b*) most probably is deoxyribonucleic acid. It alone disappeared from the patterns after the preparations were incubated overnight in the cold with deoxyribonuclease, and it was resistant to trypsin. Sedimentation coefficients of the peaks remaining in the preparation after deoxyribonuclease digestion increased significantly because of the lowered viscosity of the solution.

After nitrogen-starved photosynthesizing cells are returned to the complete medium for 18 hr., the protein content is restored, but the ribonucleic acid content on a dry-weight basis is greater than that of normal cells. The base composition of the total nucleic acids is once more the same as that of normal cells[3]. Ultracentrifuge patterns from the 18-hr. nitrogen-restored photosynthesizing cells closely resemble the patterns from normal cells (Fig. 1*a*); but the ultracentrifuge patterns from the nitrogen-restored chlorophyll-less mutant cells again resemble those from proliferating yeast cells (Ashikawa, in ref. 1) more closely than they resemble the patterns from photosynthesizing *Chlorella* cells. These differences between the two strains of cells probably reflect the metabolic changes produced by the loss of photosynthetic ability in the mutant cells, resulting in heterotrophic rather than autotrophic nutrition.

We may conclude that the number and kinds of macromolecular organelles in the *Chlorella* cell closely reflect the nutritive conditions under which the alga is grown; further, that the changes in the macromolecular architecture of the alga may be correlated with marked changes in its chemical composition.

This study was supported in part by Grant No. C–3987 from the National Cancer Institute of the U.S. Public Health Service, and by a grant from the General Research Fund of the University of Kansas.

[1] Roberts, R. B. (ed.), "Microsomal Particles and Protein Synthesis" (Pergamon Press, New York, 1958.)

[2] Schachman, H. K., Pardee, A. B., and Stanier, R. Y., *Arch. Biochem. Biophys.*, **38**, 245 (1952).

[3] Newmark, P., and Fujimoto, Y., *Fed. Proc.*, **18**, 293 (1959).

[4] Fogg, G. E., "New Biology," **15**, 99 (1953); "The Metabolism of Algae" (John Wiley and Sons, Inc., New York, 1953).

[5] Virtanen, A. I., and Miettinen, J. K., *Acta Chem. Scand.*, **3**, 1437 (1949).

[6] Dagley, S., and Sykes, J., *Nature*, **179**, 1249 (1957).

[7] Bald, H. C., *Bull. Torrey Botan. Club*, **76**, 101 (1949).

[8] Ts'o, P. O. P., Bonner, J., and Vinograd, J., *J. Biophys. Biochem. Cytol.*, **2**, 451 (1956).

[9] Ts'o, P. O. P., Bonner, J., and Vinograd, J., *Biochim. Biophys. Acta*, **30**, 570 (1958).

[10] Lyttleton, J. W., *Biochem. J.*, **64**, 76 (1956).

[11] Dorner, R. W., Kahn, A., and Wildman, S. G., *Biochim. Biophys. Acta*, **29**, 240 (1958).

[12] Chao, F., *Arch. Biochem. Biophys.*, **70**, 426 (1957).

[13] Wolfe, R. G., *Arch. Biochem. Biophys.*, **63**, 100 (1956).

APPARENT OBSERVATION OF SOLAR CORPUSCULAR CLOUDS BY DIRECT CONTINUOUS-WAVE REFLEXION

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BEGINNING at about 1.31 a.m. E.S.T. on the morning of April 15, 1959, several unique Doppler signals were recorded at the Ohio State University Radio Observatory which may possibly be due to the reflexion of continuous-wave signals from fast-moving solar corpuscular clouds passing in the vicinity of the Earth. The receiver in use at the time was a swept-frequency type with its centre frequency on 15 Mc./s. for the reception of *WWV* (Washington, D.C.). The receiver had a 1-kc./s. bandwidth and was swept about twice a second over a frequency-range of about 9 kc./s. (4·5 kc. above and below 15 Mc.). The receiving antenna was a horizontally polarized corner reflector of 1,360 sq. ft. physical aperture rotating in azimuth about 6 r.p.m. The receiver output modulated the *z*-axis of a cathode ray oscilloscope which was photographed on 35 mm. film moving about 2 cm. per min., giving a display of frequency versus time with fiducial marks along the time axis to indicate when the antenna was pointed in a reference direction (approximately south). Except for the swept-frequency receiver and rotating directional antenna, the technique was the same continuous-wave reflexion method used at the Ohio State Radio Observatory since December 1957 for the detection of ionization induced by artificial Earth satellites[1-3]. The swept-frequency receiver had been added for the observations of any Doppler shifts of the reflected signals and the rotating antenna for the observation of the direction of signal arrival.

Fig. 1 is a photograph of the swept-frequency record obtained with the above equipment between about 1.30 and 1.36 a.m. E.S.T. on April 15, 1959. Frequency extends transversely with 15 Mc./s. at the centre and 15 Mc. minus 5 kc./s. at the top and 15 Mc. plus 4 kc./s. at the bottom. The row of dots at the top of the film are the direction fiducial marks. The central heavy trace is the 15 Mc./s. signal from *WWV* (and/or *WWVH*).

Of particular interest on this record are the two strong signals which sweep rapidly from high to low frequency through the band of reception at 1.31 and 1.34 a.m. The fact that they change from high to low frequency suggests that they might be Doppler shifted signals reflected from rapidly moving ionized clouds. Beginning about 1.45 a.m. many other apparent Doppler signals were recorded on the film until about 3.25 a.m., after which all such indications disappeared. All the signals after 1.45 a.m. differ from the two of Fig. 1 in that they persist much longer, have a periodic fluctuation of several kilocycles, and have a smaller maximum frequency deviation. Fig. 2 is a typical example of one of these signals recorded about 2.35 a.m.

The signal at 1.31 a.m. has a rate of frequency-change of more than 400 c./s. per sec., and if it is a true Doppler reflexion of *WWV* must have a maximum frequency deviation of at least 20 kc. or several times as great as the receiver sweep-range. The signal at 1.34 a.m. has a lower rate of change of frequency and also appears to be quite asymmetrical, having the appearance of a segment of a Doppler curve at a considerable frequency deviation from the original frequency. Thus, this signal might have been caused by a Doppler shift of another station transmitting on a frequency greater than 15 Mc./s.

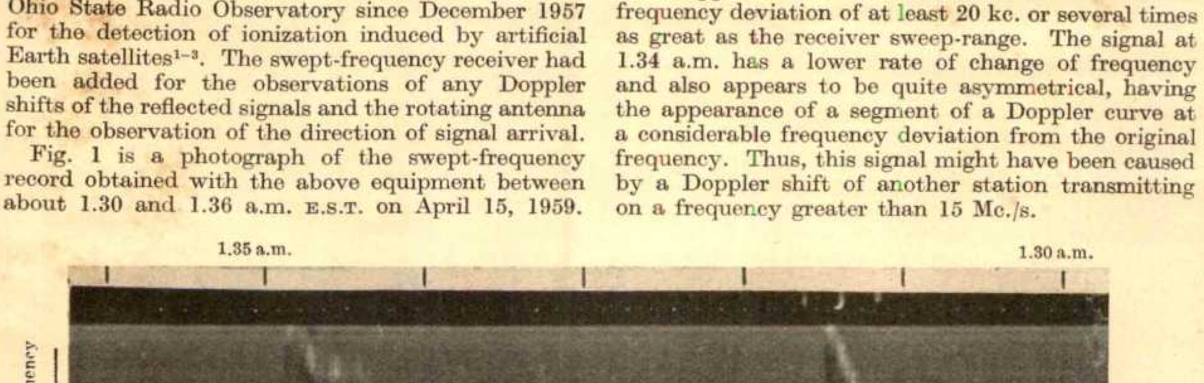

Fig. 1. Swept-frequency record of Doppler signals recorded between 1.30 and 1.36 a.m. (E.S.T.) on April 15, 1959. Frequency extends transversely with 15 Mc./s. at the centre and 15 Mc. minus 5 kc./s. at the top and 15 Mc. plus 4 kc./s. at the bottom. Time increases to the left. The dots along the top of the film are the direction fiducial marks

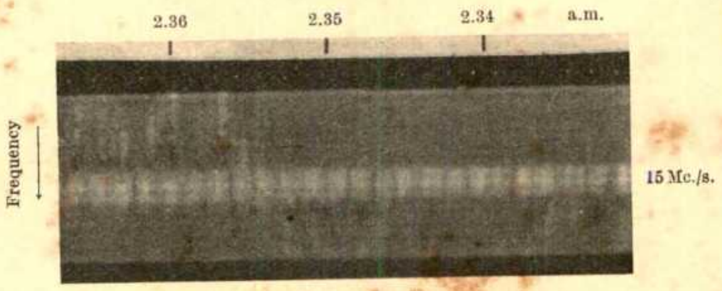

Fig. 2. Swept-frequency record of Doppler signals recorded about 2.35 a.m. on April 15, 1959. These signals show less frequency deviation but have more frequency spread and a periodic fluctuation suggesting turbulence

The limited frequency-range of the sweep system (9 kc./s.) prevents an accurate determination of the maximum frequency deviation. However, various considerations would place the maximum deviation between 20 and 80 kc./s. These values imply a velocity of the reflecting cloud of between 200 and 800 km. per sec.

It may be significant that about two days earlier a large solar flare occurred near the central meridian of the Sun. This flare reached its maximum about 0900 U.T. on April 13, 1959, and was rated of importance 3 (highest rating) by the High Altitude Observatory of the University of Colorado[4]. Material ejected by this flare travelling at an average velocity of 900 km. per sec. would have reached the vicinity of the Earth at about 1.30 a.m. (E.S.T.) (0630 U.T.) on April 15, when the first Doppler signal was observed. An average velocity of 900 km. per sec. is not uncommon for flare-ejected material, terrestrial magnetic and other effects being observed typically about two days after large solar flares. Hence, the radio reflexions on April 15 could have occurred from ionized clouds forming part of corpuscular streams ejected from the Sun by the flare of April 13, the velocity at the time of the radio observations having decreased considerably below the average value.

All the signals recorded between 1.45 a.m. and 3.25 a.m., such as shown in Fig. 2, appear to have a Doppler spread of several kilocycles, with the later signals appearing to have a greater frequency dispersion than the earlier ones. The signal in Fig. 2 has a frequency spread or dispersion of at least 4 kc./s. They also appear to possess a periodic fluctuation around a more slowly varying average frequency. This fluctuation amounts to a couple of kilocycles and is suggestive of turbulence in the clouds. The maximum deviation of the average frequency for these signals is about 4 kc./s., which corresponds to a velocity of 40 km. per sec. Hence, these signals could be interpreted as due to reflexions from slower-moving turbulent clouds following in the wake of the high-velocity cloud recorded in Fig. 1, and apparently trapped in the Earth's magnetic field.

A number of terrestrial phenomena occurred early on April 15 which also suggest the possible arrival of solar particles in the Earth's vicinity at that time. For example, the recordings of the Earth's magnetic field at the Magnetic Observatory at Agincourt, Ontario, Canada[5], show fluctuations between 1.00 and 2.00 a.m. E.S.T. with little or no variations for the 3 hr. preceding 1.00 a.m. and the 5 hr. following 2.00 a.m. The maximum increase in declination (east) amounts to about 22γ with its highest values centred about 1.20 a.m., or 11 min. before the first radio Doppler signal, compared to less than 6γ maximum variation in the adjacent 8 hr. Of particular interest is the fact that the maximum declination variation is more than twice that of the other field components. It may be significant in this connexion that an ion cloud travelling radially away from the Sun and passing near the northern hemisphere of the Earth would produce a change in the approximately east–west component of the Earth's field (declination) which would be larger than the change in the other components (north and vertical) as observed at Agincourt. The fact that the declination increase was eastward implies a cloud with a net positive charge.

The direction indications provided by the rotating receiving antenna indicate that the first Doppler signals (at 1.31 and 1.34 a.m.) were received from a generally north-western direction. This direction is consistent with that to be expected for clouds from the Sun passing by the Earth above the northern hemisphere, since as observed from Columbus clouds approaching from the Sun would be observed (in azimuth) to come from the north. The later Doppler signals (after 1.45 a.m.) show a direction of arrival which is also generally to the north with some appearing to begin toward the north-west and changing to a north-east or easterly bearing.

It is of interest to calculate the distance of the ionized clouds at their point of near approach and also their radar cross-section. Based on a frequency deviation of at least 20 kc./s. (but not more than 80 kc./s.) and a maximum rate of change of frequency of 410 c./s. per sec., a distance of at least 10,000 km. (but not more than 160,000 km.) is obtained for the initial cloud (Fig. 1). The calculated radar cross-section of this cloud is at least 100 sq. km. (but not more than about 5×10^4 times this value). For the later clouds, the maximum (average) frequency deviation is typically about 4 kc./s. and the maximum rate of change of frequency about 75 c./s. per sec. Hence, these clouds were about 2,000 km. distant at near approach and had radar cross-sections of about 0·2 sq. km. each. In order to reflect the 15 Mc./s. signals electron densities in the clouds of the order of 10^{12} per cu.m. are required. From various considerations it appears that the clouds contained positive ions, electrons and perhaps neutral matter.

The above observations are suggestive of Doppler reflexions from solar corpuscular clouds. So far as we are aware, moving solar corpuscular clouds have not previously been detected by direct radio (or radar) techniques; so if the interpretation of the results is correct this marks the first observation of its kind.

The work reported here was supported in part by the Army Rocket and Guided Missile Agency, U.S. Army Ordnance Missile Command, under Contract *DA*-33-019-*ORD*-2867 with the Ohio State University Research Foundation.

[1] Kraus, J. D., *Proc. Inst. Rad. Eng.*, **46**, 610 (1958).

[2] Kraus, J. D., Higgy, R. C., and Albus, J. S., *Proc. Inst. Rad. Eng.*, **46**, 1534 (1958).

[3] Kraus, J. D., and Dreese, E. E., *Proc. Inst. Rad. Eng.*, **46**, 1580 (1958).

[4] Preliminary Reports of Solar Activity, Report *TR* 398 for week ending April 17, 1959, High Altitude Observatory, Boulder, Colorado.

[5] Indices of Geomagnetic Activity for Agincourt, Ontario, Division of Terrestrial Magnetism, Dominion Observatory, Ottawa, Ontario, Canada.

FLUCTUATIONS IN PHOTON STREAMS

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BRIEF mention was made in a previous communication[1] of the way in which photon fluctuations have been studied in connexion with the performance of detectors of radiation, particularly for the infra-red region The ability to detect small radiation signals despite the inevitable presence of noise in the device is called detectivity Milatz and van de Velden[2] were the first to recognize that a limit to the detectivity of a thermal detector is set by the spontaneous fluctuations in temperature as given by the Einstein–Fowler formula[3]

$$\overline{\Delta E^2} = kT^2 \frac{\partial E}{\partial T} \qquad (1)$$

where E is the energy in the receiver, T the absolute temperature and k the Boltzmann constant

The mean square fluctuation $\overline{\Delta n^2}$ in the density of photons in a temperature enclosure is (see ref 3)

$$\overline{\Delta n^2} = n + \frac{n^2}{N} \qquad (2)$$

where n is the mean density of photons, and N the density of Bose cells The first term in equation 2 is equal to the fluctuation $\overline{\Delta n^2} = n$ in a random set of classical particles having mean density n The second term is similarly identifiable with the fluctuation $\overline{\Delta n^2} = n^2/N$ in the squared amplitude in a random set of classical waves The total fluctuation can therefore be regarded as comprising a 'classical particle' part, n, and a 'classical wave' part, n^2/N

Lewis[4] used equation 2 to calculate the fluctuation in the energy exchanged by a black receiver with an isothermal cavity, and found the same limit to the detectivity as had been derived by Milatz and van de Velden Clark Jones[5] showed that this agreement provides a means of using equation 1 to calculate the limiting detectivity of any radiation receiver in equilibrium with an isothermal enclosure, whatever may be its spectral responsivity and whether or not its mechanism is thermal The result may be summarized by saying that in each small frequency-range the mean square fluctuation in the number m of photons affecting a detector having quantum efficiency ε is

$$\overline{\Delta m^2} = m\left(1 + \frac{n}{N}\right) \qquad (3)$$

where

$$m = \tfrac{1}{4}\varepsilon c n A \qquad (4)$$

$$n = N/(\exp h\nu/kT - 1) \qquad (5)$$

$$N = 8\pi\nu^2 d\nu/c^3 \qquad (6)$$

A is the effective surface area of the receiver, c the velocity of light, ν the wave frequency, and h the Planck constant.

These developments have led to an understanding that the detectivity of radiation receivers is subject to limitations which do not essentially depend on the particular mechanism (whether photo-emissive, photoconductive, thermal or phase-coherent), but are determined by the extent to which its wave-length responsivity causes the detector to be susceptible to the fluctuations in the ambient thermal radiation. These photon-fluctuations became of practical interest when it was found[6,7] that some of the best actual detectors of infra-red radiation had detectivities close to the limit set by equation 3 In the Rayleigh–Jeans approximation $\nu \rightarrow 0$, equation 3 also represents the ordinary Johnson noise in the radiation resistance of an antenna[6]

Photon fluctuations have acquired renewed interest with the demonstration[8] that partial coherence of visible light can be measured by means of the correlation between fluctuations in the photocurrents in two photocells The experiments have occasioned some surprise, and it has even been suggested that non-zero correlation would be contrary to fundamental quantum notions On general correspondence principle grounds, however, the properties of radiation which admittedly make fluctuation interferometry possible in the radio region[9,10] cannot just disappear at optical wave-lengths ; there must be some gradual transition through the infra-red Correlation between the signals from two coherently illuminated cells arises from the 'wave' fluctuations, and provides the only means so far known of investigating this component experimentally for visible light. The 'particle' fluctuations at the two cells are mutually uncorrelated, and act as noise tending to mask the effect which it is desired to measure The familiar transition (equation 3) in the infra-red from the predominance of 'wave' noise to that of 'particle' noise as the wave-length shortens makes it clear[1] that the 'wave' component is indeed always present, but that it becomes increasingly smothered by the 'particle' noise as the optical region is approached, so that a refined method is needed to measure it

A difficulty remained, however[1,11] Hanbury Brown and Twiss developed a theory of the fluctuation in the output of a photocell which was based on the analysis of the detailed interaction between the photoelectrons and the radiation field It gives results consistent with the picture that photons 'arrive' at random, subject to the probability of 'arrival' being proportional to the instantaneous value of the square of the classical electric vector of the incident radiation A statistical approach of this kind had been abandoned in earlier work on fluctuations affecting radiation detectors because of the apparent difficulty of making the arguments rigorous[12] The predictions of this theory are in agreement with the correlation found experimentally by Hanbury Brown and Twiss in the fluctuation interferometer Applied to the fluctuation in the radiation exchanged by a receiver with an isothermal enclosure, however, the theory apparently gives

$$\overline{\Delta m^2} = m\left(1 + \frac{\varepsilon n}{N}\right) \qquad (3a)$$

where ε is the emissivity of the receiver The 'wave' noise in this equation is smaller by a factor ε than that given by equation 3 If equation $3a$ were correct under these conditions, the fluctuation temperature of a grey body in thermal equilibrium with a cavity would not be the same as the temperature of the cavity A heat engine could then be arranged to work between the body and the cavity so as to give mechanical work in a *perpetuum mobile* of the second kind[1] This may be regarded as unacceptable, either because it contradicts the second law of thermodynamics, or because it conflicts with microscopic reversibility

It is central to the problem that any conflict between equations 3 and $3a$ can refer only to the behaviour in an isothermal enclosure, since although the derivation of equation $3a$ was believed to be quite general, the arguments leading to equation 3 explicitly assumed thermodynamic equilibrium It has been pointed out[12,13] that for this reason no unambiguous induction had been made from equation 3 to conditions outside a cavity This, incidentally, logically disposes of the assertion sometimes made that fluctuation interferometry outside a cavity is able to decide directly the correctness of equation 3

In considering how the difficulty can be resolved, it now seems clear that a number of the objections to the thermodynamic approach originally put forward by Hanbury Brown and Twiss[11] are invalid Thus it is not correct that detailed balancing in aged systems applies only to the energy flow itself and not to the fluctuations, as this would imply that microscopic reversibility did not hold, a consequence for which there is no justification Furthermore, the non-linear relation between the loss of heat from a thermal detector and its temperature does not significantly affect the derivation used by Jones and Fellgett The significant non-linearity is the square-law relation between the mean photon-rate and the amplitude of the classical electromagnetic wave, which implies that the fluctuation in the sum of two radiation streams is not generally equal to the sum of the fluctuations in the two separate streams This non-additive property corresponds to the 'bunching' of photons in Bose–Einstein statistics, and is represented classically by 'beats' between the component wave-amplitudes The general statistical-thermodynamic considerations on which the deviation of Jones and Fellgett is based include such effects automatically , they do not have to be taken into account explicitly, as they would, of course, in a derivation based on consideration of the detailed mechanism of exchange of radiation

On the other hand, Jones[5] and Fellgett[6], in assessing the fundamental noise-level in radiation detectors exposed to room temperature radiation, had attempted to include, as well as detectors in equilibrium, detectors in which 'active' radiation is suppressed either by cooling, as in superconducting bolometers or lead-compound photoconductive cells, or by applying an electric field to a photocell , 'active' radiation here means radiation-emitting transitions which cause a change in the output of the device, for example, the radiative return of an electron to the conduction band in a photoconductive cell To cover such cases, Jones and Fellgett assumed that the fluctuation given by equation 3 could be expressed as the sum of two independent terms, one associated with the radiation absorbed and the other with that emitted, so that only the part thus ascribed to the incident radiation would contribute to the fluctuations in the outputs of strongly cooled detectors or of photoemissive cells with voltage applied Since the derivation of equation 3 assumes equilibrium, this extension of the use of the equation could be justified only by additional physical considerations, which they attempted to supply

It now appears that this procedure is wrong, not only quantitatively but also conceptually, because it fails to take account of the possible interaction between the radiation incident on the detector and that radiated by it, and so assumes falsely that the noise in these two streams behaves additively Moreover, the recognition of this interaction enables the fluctuation theory developed by Hanbury Brown and Twiss to be applied to the exchange of radiation in a cavity in a way which agrees with thermodynamics

To illustrate this in a special case, consider the exchange of radiation between two cavities at temperatures T_1 and T_2 separated by a non-absorbing semi-reflecting mirror having energy transmission ε and reflectivity $1 - \varepsilon$ Let E_1 be the modulus of the electric vector corresponding to the radiation emitted by the T_1-region and incident at a point of the mirror, and $E_1\sqrt{(1-\varepsilon)}$ the electric vector corresponding to the radiation reflected back towards the T_1 region Similarly, let E_2 be the modulus of the electric vector corresponding to the radiation emitted by the T_2-region towards the T_1-region Since there is no coherent phase relation between E_1 and E_2, the field corresponding to the radiation transmitted by the mirror into the T_1-region can be represented without loss of generality by the vector $E_2\sqrt{\varepsilon}$ Then the difference between the rate at which energy is absorbed and emitted by the T_2-region according to classical wave theory is proportional to

$$E_1^2 - (E_1\sqrt{(1-\varepsilon)} + E_2\sqrt{\varepsilon})^2$$
$$= \varepsilon(E_1^2 - E_2^2) - 2E_1E_2\sqrt{\{\varepsilon(1-\varepsilon)\}}$$

The mean square deviation of this quantity from its mean value $\varepsilon(\overline{E_1}^2 - \overline{E_2^2})$ is

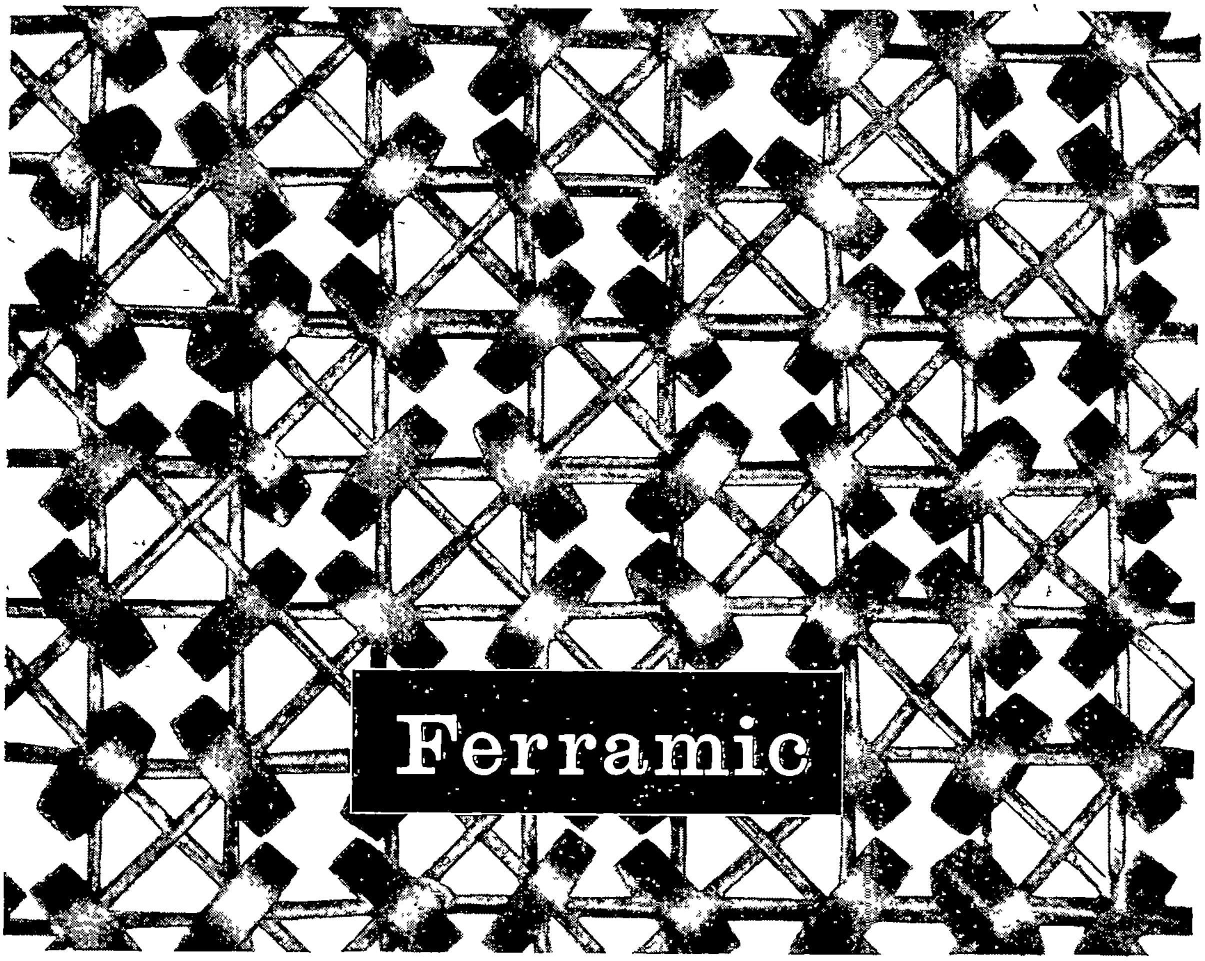
$$\varepsilon^2\{(E_1^2 - \overline{E_1}^2)^2\}_{\text{av}} + \varepsilon^2\{(E_2^2 - \overline{E_2}^2)^2\}_{\text{av}} + 4\cdot(1-\varepsilon)\,\overline{E_1^2}\;\overline{E_2^2}$$

under the condition $\overline{E_1E_2} = 0$ If E_1, E_2 have Gaussian probability distribution, $\{(E^2 - \overline{E}^2)^2\}_{\text{av}} = 2(\overline{E^2})^2$ and the expression reduces to

$$2(\varepsilon^2I_1^2 + 2\varepsilon(1-\varepsilon)I_1I_2 + \varepsilon^2I_2^2) \qquad (7)$$

where $I_1 = \overline{E_1^2}$, $I_2 = \overline{E_2^2}$ The fluctuation in the radiation exchanged through a finite area of the mirror is equal to the product of this expression with a factor which can be evaluated in the usual way by considering the variation of the coherence in space and time

The T_2-region and the mirror can together be regarded as constituting a body with emissivity ε



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exchanging radiation with the T_1-region For example, it may represent a detector made of a material which absorbs all the radiation entering its substance but which has a dielectric constant differing from that of its surroundings so that partial reflexion occurs at its surface If $T_1 = T_2$, the average energies I_1 and I_2 radiated by the T_1- and T_2-regions are equal, and the expression 7 reduces to $4\varepsilon I^2$ The mean square fluctuation is therefore proportional to ε, and this accords with the form of the wave-noise term $\overline{\Delta m^2} = mn/N$ in equation 3 (since m contains ε as a factor, see equation 4) By contrast, if $T_1 \gg T_2$, I_2 can be neglected and expression 7 tends to $2\varepsilon^2 I^2$ This shows that the mean square fluctuation now varies as ε^2 in accordance with the wave term $\overline{\Delta m^2} = \varepsilon mn/N$ in equation 3a

For a detector conforming to this model, the previous difficulties have now been resolved Equation 3a is seen to be correct under the conditions of the experiments made by Hanbury Brown and Twiss, namely, when the emitted radiation field is effectively zero , but not for detectors which are hot enough to radiate appreciably Equation 3 is correct when applied to the exchange of radiation between a cavity and a detector in equilibrium , but not with the extended interpretation ascribed to it by Jones and Fellgett In reaching these conclusions, it has been necessary to consider not only interaction between the absorbed and the emitted radiation, but also interactions involving both the reflected radiation and that radiation which is regarded as 'virtually emitted' if we consider the detector as an assembly of classical or quantized oscillators

It is not certain that the model is completely general The discussion given above is purely classical-wave, and a quantum-mechanical approach is needed in which stimulated emission replaces the classical wave-interference effects This method will automatically include a 'particle' term as well as the 'wave' term, and may show what happens when there are competing mechanisms of absorption of radiation, one of which is 'active' in producing output from the cell whereas the others are not

Despite these limitations, it seems very plausible (to put it no higher) that equation 3 is correct generally when the detector is at the temperature of the radiation field in which it is placed , and that equation 3a becomes true in the limit when the detector is too cool to radiate appreciably The effect of these conclusions on the calculation of the limiting detectivity of radiation detectors remains to be investigated in detail

It now appears, therefore, that the discrepancy, which was pointed out in earlier publications, between the fluctuation formula derived by Jones and Fellgett on one hand, and by Hanbury Brown and Twiss on the other, was real and that it showed limitations in both methods of calculation as they were then conceived The two formulæ have now been reconciled, and each found to be correct in the circumstances for which it was originally derived, by taking account of the interaction between the incident, emitted and reflected radiation streams, the relevance of which had not previously been appreciated

[1] Fellgett, P B , *Nature*, **179**, 956 (1957)
[2] Milatz, J M W , and van de Velden, H A , *Physica*, **10**, 369 (1943)
[3] Fowler, R H , "Statistical Mechanics" (Camb Univ Press, 1929)
[4] Lewis, W B , *Proc Phys Soc* , **59**, 34 (1947)
[5] Jones, R C , *J Opt Soc Amer* , **37**, 879 (1947)
[6] Fellgett, P B , *J Opt Soc Amer* , **39**, 970 (1949)
[7] Moss, T S , *J Opt Soc Amer* , **40**, 603 (1950)
[8] Hanbury Brown, R , and Twiss, R Q , *Nature*, **177**, 27 (1956) , **178**, 1046 (1956)
[9] Hanbury Brown, R , and Twiss, R Q , *Phil Mag* , **45**, 663 (1954)
[10] Hanbury Brown, R , Jennison, R C , and Das Gupta, M K , *Nature*, **170**, 1061 (1956)
[11] Hanbury Brown, R , and Twiss, R Q , *Nature*, **179**, 1128 (1957) , *Proc Roy Soc* , A, **242**, 300 (1957)
[12] Fellgett, P. B , thesis, Univ Camb (1951)
[13] Fellgett, P B , "Vistas in Astronomy", 478, edit A Beer (Pergamon Press, London, 1955)

By Dr C. W. McCOMBIE

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Two contradictory views on the fluctuations in the absorption and emission of photons by matter have been discussed in recent papers[1-3]. Both views agree that the mean square fluctuation, $\overline{\Delta N^2}$, in the number N of photons in a small frequency-range absorbed or emitted in unit time by a black body will exceed the value $\bar{N}$, appropriate to Poisson fluctuations, by a factor $1 + \bar{n}$ here $\bar{n}$ is the mean number of photons in one of the electromagnetic modes concerned and is given by $\{\exp(h\nu/kT) - 1\}^{-1}$ The disagreement arises when the body absorbs imperfectly According to one view[1,4,5], the fluctuations in the number of photons absorbed (or emitted) will exceed Poisson fluctuations by the factor $1 + \bar{n}$, no matter how small the fraction of incident photons absorbed This opinion claims support from the quasithermodynamic type of argument, given by Clark Jones[6] and by Fellgett[4], and generally used to establish the ultimate sensitivity limits for radiation detectors The other view[2,3] maintains that the random selection of photons for absorption tends to make the fluctuations approach a Poisson distribution more precisely, the factor $1 + \bar{n}$ is reduced to $1 + \varepsilon\bar{n}$, where ε is the absorptivity This second view is supported by detailed calculations[3,7] concerned primarily with the photon correlation experiments of Hanbury Brown and Twiss[7]

In this communication the quasithermodynamic approach will be applied to a particular model The results agree with the detailed calculations in supporting the *second* point of view, and for this model, at least, the conflict is resolved The agreement depends on taking account of the fact that, because of stimulated emission, the radiation emitted by matter depends in general on the radiation field into which it radiates the mean rate at which an atom radiates into an electromagnetic mode is proportional to $1 + \bar{n}$ (cf Heitler[8]) This effect must be allowed for whenever, as in the disagreement under discussion, $1 + \bar{n}$ is distinguished from unity The results also agree with the standard formula for the ultimate sensitivity limit of radiation detectors derived by Clark Jones and Fellgett, although, as mentioned, it has been claimed that this formula supports the *first* view This claim depends on the assumption that the mean rate at which the detector absorbs radiation from a black body radiation field with which it is in equilibrium can be equated to the absorptivity multiplied by the rate of incidence of the black body radiation on the detector · it will emerge that, because of stimulated emission effects, this equality does not hold for the model to be considered here

In the quasithermodynamic approach the system concerned is characterized by the coefficient α, where $\alpha\Delta T$ is the rate of loss of heat from the system when its temperature exceeds that of the surroundings by ΔT The basic result used is the following analogue of Nyquist's theorem when the system and its surroundings are both at temperature T, the mean square fluctuation in the energy absorbed or emitted in unit time by the system in thermal exchange with its surroundings is $\alpha k T^2$ This result reduces the calculation of the magnitude of the fluctuations to the calculation of α

The importance of considering stimulated emission can be seen very simply by considering the fluctuations for a set of very weakly absorbing and emitting atoms The photon absorption-rate will equal a constant θ_T, depending on the number, nature and temperature of the atoms, multiplied by $\bar{n}$, the mean number of photons in an electromagnetic mode in the (small) range of frequencies absorbed by the atom To determine α, we suppose the surroundings at temperature T and the atoms at temperature $T + \Delta T$ Since the atoms radiate and absorb weakly, $\bar{n}$ will have the value $\bar{n}_T$ appropriate to the temperature of the surroundings. The rate of absorption of photons will be $\theta_{T+\Delta T}\,\bar{n}_T$ and, with neglect of stimulated emission effects, the rate of emission would equal that of atoms in equilibrium with radiation at $T + \Delta T$, which must equal the rate of absorption from this radiation, that is, $\theta_{T+\Delta T}\,\bar{n}_{T+\Delta T}$ But because the atoms are actually radiating into radiation at temperature T, not $T + \Delta T$, and for a given state of the emitter the radiation is proportional to $1 + \bar{n}$, the rate of emission must be modified to $\theta_{T+\Delta T}\,\bar{n}_{T+\Delta T}(1 + \bar{n}_T)/(1 + \bar{n}_{T+\Delta T})$ Substitution of the resulting value (note that $\mathrm{d}\bar{n}/\mathrm{d}T$ can be written $\bar{n}\,(1+\bar{n})\,h\nu/kT^2$) of α in the quasi-thermodynamic result gives $\theta_T\,\bar{n}_T$ for $\overline{\Delta N^2}$ This represents Poisson fluctuations, in agreement with the second view, since the absorption is small Neglect of stimulated emission introduces an extra factor $1 + \bar{n}$, lending spurious support to the first view

The main model to be considered here consists of a large cavity filled with a tenuous gas of atoms which absorb only in a small frequency-range around ν at a rate again specified by θ_T. the walls are perfectly reflecting apart from a small opening, of area A, to the outside Radiation, which enters the cavity from the outside and re-emerges after being reflected around but not absorbed by an atom, is to be regarded as scattered Thus the model can be adjusted to represent arbitrary ε

To determine α and ε for the model, it is necessary to consider non-equilibrium situations in which $\bar{n}_{\mathrm{inc}}$, the number of photons per mode in the radiation incident on the aperture from the outside, differs from the value $\bar{n}_T$ appropriate to the temperature of the atoms The number of photons per mode in the cavity will then differ from $\bar{n}_T$, it will be supposed, however, that $\bar{n}$ has the same value, denoted by $\bar{n}_c$, for all modes of frequency ν in the cavity The value of $\bar{n}_c$ is fixed by the energy balance requirement that the net rate of emission of photons through the aperture, $(\bar{n}_c - \bar{n}_{\mathrm{inc}})\varphi$, where φ is a constant fixed by A and ν, must equal the net rate of emission of photons by the atoms, so that

$$(\bar{n}_c - \bar{n}_{\mathrm{inc}})\varphi = \theta_T\,\bar{n}_T(1 + \bar{n}_c)/(1 + \bar{n}_T) - \theta_T\,\bar{n}_c \quad (1)$$

where stimulated emission effects have been treated as before

In order to determine α the surroundings are supposed at temperature T, so that $\bar{n}_{\mathrm{inc}}$ is $\bar{n}_T$, and the atoms at temperature $T + \Delta T$ The net rate of energy loss $\varphi(\bar{n}_c - \bar{n}_T)$, evaluated to the first order in ΔT, gives α The preliminary determination of $\bar{n}_c$ follows from (1) with $\bar{n}_{\mathrm{inc}}$ and T replaced by $\bar{n}_T$ and $T + \Delta T$ The quasithermodynamic result then gives

$$\overline{\Delta N^2} = \frac{\alpha k T^2}{(h\nu)^2} = \frac{\theta_T\varphi(1 + \bar{n}_T)\bar{n}_T}{\theta_T + \varphi(1 + \bar{n}_T)} \quad (2)$$

Because of stimulated emission, ε_T, which can be regarded either as the emissivity or the absorptivity, must be defined rather precisely, but the appropriate operational definitions are clear As the emissivity, ε_T would be determined by letting the system, with the atoms at temperature T, radiate in the absence of incident radiation, and taking the ratio of the emitted radiation $\varphi\bar{n}_c$ to that from a black body of the same area and temperature, namely, $\varphi\bar{n}_T$ As the absorptivity, ε_T, would be found by increasing the incident radiation slightly above its equilibrium value, so that $\bar{n}_{\mathrm{inc}}$ exceeds $\bar{n}_T$, and taking the ratio of the net rate of absorption of radiation, $(\bar{n}_{\mathrm{inc}} - \bar{n}_c)\varphi$, to the extra rate of incidence, $(\bar{n}_{\mathrm{inc}} - \bar{n}_T)\varphi$, the values of $\bar{n}_c$ in the two cases are easily determined from equation 1 The results for ε_T agree, being given by .

$$\varepsilon_T = \frac{\theta_T}{\theta_T + \varphi(1 + \bar{n}_T)} \quad (3)$$

$\overline{N}_T$ is the mean flux of photons which, when system and surroundings are at temperature T, proceed from atoms of the gas to the outside without intervening absorption, as distinct from (*a*) photons which enter and leave without absorption, or (*b*) those which are emitted by an atom and absorbed by an atom without leaving the cavity Only a fraction $\varphi/(\theta_T + \varphi)$ of the radiation emitted by an atom will escape, the rest being re-absorbed The atoms will radiate at the rate $\theta_T\bar{n}_T$ Consequently

$$\overline{N}_T = \frac{\varphi\theta_T\,\bar{n}_T}{\theta_T + \varphi} \quad (4)$$

It may be noted that $\overline{N}_T$ exceeds $\varepsilon\varphi\bar{n}_T$, the rate of emission in the absence of incident radiation The ratio of the two, $(1 + \bar{n}_T)/(1 + \varepsilon\bar{n}_T)$, is just the stimulated emission factor corresponding to the different values of $\bar{n}_c$

According to equations 2, 3 and 4, $\overline{\Delta N^2}$ can be expressed in two algebraically equivalent forms

$$\begin{aligned}\overline{\Delta N^2} &= \varepsilon\varphi\bar{n}_T(1 + \bar{n}_T) \\ &= \overline{N}_T(1 + \varepsilon\bar{n}_T)\end{aligned} \quad (5)$$

The first form reproduces the result used in the theory of the ultimate limit of radiation detectors The second exhibits for this model the complete agreement between the results of the quasithermodynamic discussion and the results of the detailed approach of Hanbury Brown and Twiss

I am indebted to my colleagues, Drs E W Elcock and P T Landsberg, for their comments on this communication, and to Dr P B Fellgett for correspondence on preliminary versions of this and the preceding communication by Fellgett, Clark Jones and Twiss

[1] Fellgett, P B , *Nature*, **179**, 956 (1957)

[2] Twiss, R W , and Hanbury Brown, R , *Nature*, **179**, 1129 (1957)

[3] Hanbury Brown, R , and Twiss, R Q , *Proc Roy Soc* , A, **242**, 300 (1957)

[4] Fellgett, P B , *J Opt Soc Amer* , **39**, 970 (1949)

[5] McCombie, C W , "Rep Progr Phys ", **16**, 266 (1953)

[6] Jones, R Clark, *J Opt Soc Amer* , **37**, 879 (1947)

[7] Purcell, E M , *Nature*, **178**, 1449 (1956) Sillitto, R M , *ibid* , **179**, 1127 (1957) Mandel, L , *Proc Phys Soc* , **72**, 1037 (1958) Kahn, F D , *Optica Acta*, **5**, 93 (1958) Hanbury Brown, R , and Twiss, R Q , *Proc Roy Soc* , A, **243**, 291 (1958)

[8] Heitler, W , "The Quantum Theory of Radiation", 3rd edit (Clarendon Press, Oxford, 1954)

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 16

Society of Chemical Industry, Pesticides Group (at 14 Belgrave Square, London, S W 1), at 9 30 a m —Symposium on "Pyrethrum"

Tuesday, November 17

University of London (at Queen Mary College, Mile End Road, London, E 1), at 1 30 p m —Prof C P Whittingham "The Challenge of Biology"

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W C 2), at 5 30 p m —Discussion on "Sequence Networks versus Summation Transformers for the Derivation of Single Quantities for Protective Relaying", opened by Mr C Adamson and Dr E A Talkhan

Research Defence Society (in the Physiology Lecture Theatre, University College, Gower Street, London, W C 1), at 5 30 p m —Prof Sir Solly Zuckerman, C B , F R S "The Inevitability of Science" (Twenty-eighth Stephen Paget Memorial Lecture)

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W C 1), at 5 30 p m —Dr C E Dalgliesh "Biochemical Aspects of Disorders of Aminoacid Metabolism" (Tenth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation Further lectures on November 19, December 1, 3, 8, 10)*

Institute of Physics (at 47 Belgrave Square, London, S W 1), at 6 p m —Dr R L F Boyd "Some Techniques and Results of Space Exploration"

Royal Aeronautical Society (at 4 Hamilton Place, London, W 1), at 7 p m —Dr J A Shercliff "Magnetogasdynamics"

Wednesday, November 18

Institute of Metal Finishing (in the Recital Room of the Royal Festival Hall, London, S E 1) at 9 30 a m —Symposium on "Progress in Polishing"

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W C 1), at 3 p m and 6 p m —Half-day Symposium on "Electronic Digitizing Techniques"

Royal Geographical Society (at 1 Kensington Gore, London S W 7), at 5 p m —Prof M E L Mallowan and Mr David Oates "Fort Shalmaneser, Nimrud"

Royal Meteorological Society (at 49 Cromwell Road, London, S W 7), at 5 p m —Dr G B Tucker "Mean Meridional Circulations in the Atmosphere", Prof H Riehl "Exchange of Heat, Moisture and Momentum between Hurricane Ella (1958) and Its Environment"

Institution of Electrical Engineers, Supply Section (at Savoy Place, London, W C 2), at 5 30 p m —Dr J S Forrest, Mr P J Lambeth and Mr D F Oakeshott "Research on the Performance of High-Voltage Insulators in Polluted Atmospheres"

Institution of Mechanical Engineers, Nuclear Panel (at 1 Birdcage Walk, Westminster, London, S W 1), at 6 p m —Discussion on "To What Extent Should Design Wait on Research for Nuclear Power Plant ?"

Wednesday, November 18—Wednesday, December 2

Building Exhibition (at Olympia, London) *

Thursday, November 19

University College (in the Anatomy Theatre, Gower Street, London, W C 1), at 1 15 p m —Dr M Mary Douglas "The Abominations of Leviticus XI (an Anthropologist's Interpretation)" *

Royal Society (at Burlington House, Piccadilly, London, W 1) at 4 30 p m —Special General Meeting to consider the Annual Report of the Council, followed by Scientific Papers

Institution of Naval Architects (at 10 Upper Belgrave Street London, S W 1), at 4 45 p m —Mr P R Crewe and Mr W J Eggington "The Hovercraft—a New Concept in Maritime Transport"

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W 1), at 5 p m —Mr F A Williams "Use of High Tension Separation in Dressing Jig Concentrate from Decomposed Columbite-Bearing Granite Nigeria", Mr M L Fitzgerald "Metallurgical Accounting and Control"

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly London, W 1) at 5 p m – Annual General Meeting Prof H Davenport "Some Recent Progress in Analytic Number Theory" (Presidential Address)

Royal Aeronautical Society (at 4 Hamilton Place London W 1), at 6 p m —Mr W P Smith "Some Recent Progress in Air Survey with special reference to Newly Developed Territories" (Fifteenth British Commonwealth Lecture)

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S W 1), at 6 p m – Dr H F W Taylor "Aspects of the Crystal Structures of Calcium Silicates and Aluminates"

Thursday, November 19—Friday, November 20

Plastics Institute (at the Royal Institute of British Architects 66 Portland Place, London, W 1)—Conference on "The Influence of Plastics in Building"

Friday, November 20

British Psychological Society, Occupational Psychology Section (in the Department of Psychology, Birkbeck College, Malet Street, London, W C 1), at 1 p m – Dr John C Webster (U S A) Making Yourself Heard"

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S W 7), at 5 15 p m —Mr C M Cade ' Radiometry, Radio-Astronomy and Infra-red Techniques"

Institution of Electrical Engineers, Education Discussion Circle (at Savoy Place, London, W C 2) at 6 p m —Discussion on 'The Ordinary National Certificate a New Look", opened by Mr T Siklos

Institution of Electrical Engineers, London Graduate and Student Section (at Savoy Place London, W C 2), at 6 30 p m —Mr G J Waddon Plastic Cables in the Telecommunications Industry"

Royal Institution (at 21 Albemarle Street, London, W 1), at 9 p m.—Sir Lawrence Bragg, F R S ' Atoms and Molecules"

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned

Assistant Lecturer or Lecturer in the Department of Philosophy—The Registrar University College of Wales, Aberystwyth (November 14)

Lecturer (with a good degree in biochemistry) in Endocrine Biochemistry, to undertake research into the endocrine aspects of carcinoma in human patients in the University Endocrine Unit at the Liverpool Radium Institute—The Registrar, The University, Liverpool 3 (November 14)

Lecturer (preferably with a veterinary qualification) in Pharmacology in the School of Veterinary Medicine—The Registrar, Trinity College, Dublin (November 16)

Joseph Lucas Student (with a good honours degree in some branch of engineering, physics or chemistry, and prepared to work for a higher degree), for research into the initiation of explosion in gases vapours and powder clouds, or into the mixing of powdered materials —The Registrar, King's College (University of London), Strand, London, W C 2 (November 20)

Head (with suitable experience and superior attainments in chemical research and analysis, and the ability to organize, lead and inspire a large scientific staff) of the Government Chemist's Laboratory, London—The Civil Service Commission, 17 North Audley Street, London, W 1, quoting Ref No S 5041/59 (November 24)

Granada Research Chair in Communication—The Registrar, University College of North Staffordshire, Keele, Staffs (November 30)

Lecturer in Organic Chemistry at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (November 30)

Lecturer in Physical Metallurgy at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (November 30)

Assistant Lecturer or Lecturer in Mathematics—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (December 1)

Lecturer (preferably with an interest in algae and fungi) in the Department of Botany, University of Natal, South Africa—The Secretary, Association of Universities of the British Commonwealth 36 Gordon Square, London, W C 1 (December 4)

Senior Lecturer in Pure Mathematics—The Secretary The Queen's University, Belfast (December 5)

Senior Lecturer or Reader (senior theoretical astrophysicist) in Physics in the Theoretical Group of the School of Physics, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London W C 1 (December 5)

Lecturer and a Senior Lecturer in Applied Mathematics at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (December 7)

Lecturer or Assistant Lecturer in Mathematics at the University College of the West Indies – The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London W C 1 (December 10)

Professor of Physical Chemistry at the University of Natal South Africa—The Secretary Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C 1 (December 11)

Chair of Mechanical Engineering—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (December 12)

Graduate to carry out a field and laboratory research programme in Crop Physiology —Professor of Agricultural Botany, The University Reading, Berks (December 15)

Lecturer in Physiology at the University of Queensland Australia—The Secretary, Association of Universities of the British Commonwealth 36 Gordon Square London, W C 1 (December 15)

Research Fellow in the Department of Radiodiagnosis – The Registrar The University, Leeds 2 (December 19)

Associate Professor (university graduate with qualifications and considerable experience in some branch of the technology of wool production or wool commerce or rural extension, and interested in the application of science to the practical problems of the sheep and wool industry) IN WOOL TECHNOLOGY at the University of New South Wales, Australia—The Agent-General for New South Wales, 56–57 Strand, London, W C 2, and the Bursar, The University of New South Wales, Box 1, Post Office, Kensington, New South Wales, Australia, marking envelope "University Appointment" (December 21)

SAVILIAN PROFESSOR OF ASTRONOMY—The Registrar, University Registry, Oxford (December 24)

ENTOMOLOGIST, Grade C (with a good honours degree in entomology (zoology), and with a particular interest in biological control work)—The Director, Commonwealth Institute of Biological Control, Science Building, Carling Avenue, Ottawa, Ontario, Canada (December 31)

AGRICULTURAL DEVELOPMENT OFFICER (aged 25–40, with considerable experience in arid/tropical agriculture based on well and flood irrigation) with the Aden Government—The Crown Agents, 4 Millbank, London, S W 1, quoting Ref M 3A 5857/T A

BIOCHEMIST, Basic Grade (graduate in chemistry, or Associate or Graduate Member of the Royal Institute) IN THE DEPARTMENT OF PATHOLOGY—The Group Secretary, Queen Elizabeth Hospital for Children, Hackney Road, London, E 2

SENIOR SCIENTIFIC OFFICER (with an honours degree in zoology, with postgraduate experience in entomology) at the West African Stored Products Research Unit, Federation of Nigeria, to undertake original investigations into problems associated with stored foodstuffs in Nigeria, and evolve methods of improving quality and reducing losses, with particular reference to losses caused by insect infestation—The Director of Recruitment, Colonial Office, London, S W 1, quoting BCD 153/14/012/T

SPECIALIST OR SENIOR SPECIALIST OFFICER, PLANT PATHOLOGIST (with a good honours degree in botany and at least two years postgraduate training or experience) in the Northern Region of Nigeria, for general plant pathology investigations—The Director of Recruitment, Colonial Office, London, S W 1, quoting BCD 63/408/039/T

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Northern Advisory Council for Further Education Twelfth Annual Report, 1958–1959 Pp 42 (Newcastle-upon-Tyne Northern Advisory Council for Further Education, 1959) [109

Tenth Annual Report of the Wildfowl Trust, 1957–1958 Edited by Peter Scott and Hugh Boyd Pp 184−32 plates (Slimbridge, Glos The Wildfowl Trust, 1959) 10*s* net [109

Institution of Electrical Engineers Monograph No 334E The Gain of Travelling-Wave Ferromagnetic Amplifiers By Dr P J B Clarricoats Pp 9 (London Institution of Electrical Engineers, 1959) [109

Plastics Today, No 1 (June, 1959) Pp 16 (London Imperial Chemical Industries, Ltd , 1959) [109

Department of Scientific and Industrial Research Factory Building Studies No 3 Floor Finishes for Factories By Dr F C Harper and P A Stone Pp v+10 (London H M Stationery Office, 1959) 1*s* 9*d* net [109

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Other Countries

Tokyo Astronomical Observatory Astronomical Bulletin (Second Series) No 113 (January 20, 1959) Meridian Observation of Right Ascension of Equatorial Stars made with Repsold Transit Instrument Preliminary Results No 14 By K Tuzi Pp 1215–1290 No 114 (April 20, 1959) Meridian Observation of Right Ascension of Moon's Limb made with Repsold Transit Instrument Report No 3 By K Tuzi and K Nagane Pp 1291–1304 No 115 (April 20, 1959) Polar Tube Observations during 1958 By N Sekiguchi and J Matsumoto Pp 1305–1308 No 116 (June 5, 1959) Meridian Observation of Right Ascension of Equatorial Stars made with Repsold Transit Instrument Preliminary Results, No 14 By K Tuzi Pp 1309–1358 (Tokyo Astronomical Observatory, 1959) [109

Institut des Parcs Nationaux du Congo Belge Exploration des Parcs Nationaux du Congo Belge, Mission J G Baer–W Gerber (1958) Fascicule 1 Helminthes Parasites Par Jean G Baer Pp 163+8 planches Exploration du Parc National de la Garamba, Mission H de Saeger, en collaboration avec P Baert, G Demoulin, I Denisoff, J Martin, M Micha, A Noirfolise, P Schoemaker, G Troupin et J Verschuren (1949–1952) Fascicule 11 Pselaphidae (Coleoptera Staphylinoidea) Par René Jeannel Pp 71 Exploration du Parc National Albert (Deuxième Série) Fascicule 10 Hemolymph of Curcurionidae and of Diptera By Charles Grégoire Pp 17+6 plates (Bruxelles Institut des Parcs Nationaux du Congo Belge, 1959) [109

Institut Royal Météorologique de Belgique Publications Série A No 10 Sur le Comportement des Pluvionetres Par Dr L Poncelet Pp 58 No 11 Contribution à l'Étude du Problème des Méthodes Actinométriques Par Roger Pastiels Pp 128 Publications Série B No 26 Le Temps en 1958 Par Dr H Sneyers Pp 48 Observations Ionospheriques, Station de Dourbes Mars 1958 Pp 26 (Uccle-Bruxelles Institut Royal Météorologique de Belgique, 1959) [109

Connecticut Agricultural Experiment Station Bulletin 606 Soils and Land Use—Hartford County, Connecticut By Alexander Ritchie and C L W Swanson Pp 36 Bulletin 607 Report on Inspection and Analysis of Commercial Fertilizers, 1957 By H J Fisher Pp 56 Bulletin 608 Root Growth in Connecticut Tobacco Soils By Henry C de Roo Pp 36 Bulletin 609 60th Report on Food Products, and the 48th Report on Drug Products, 1955 By H J Fisher Pp 80 Bulletin 610 Pollen Restoring Genes By D F Jones, H T Stinson, Jr , and U Khoo Pp 43 Bulletin 611 Selection of Physiologic Strains of *Oncopeltus* and Its Relation to Insecticide Resistance By R L Beard Pp 45 Bulletin 612 Influence of Wet-Bulb Temperature during Curing on Properties of Shade-Grown Tobacco By A Boyd Pack Pp 23 Bulletin 613 Fertilizing Connecticut Tobacco New Methods for New Needs By Henry C de Roo Pp 37 Bulletin 614 Protecting Plants from the Cold The Principles and Benefits of Plastic Shelters By Paul E Waggoner Pp 36 Bulletin 615 Periodic Regression in Biology and Climatology By C I Bliss Pp 55 Bulletin 616 Report on Inspection—Commercial Feeding Stuffs, 1957 By H J Fisher Pp 113 (New Haven, Conn Connecticut Agricultural Experiment Station, 1957 and 1958) [109

Connecticut Agricultural Experiment Station Bulletin 617 61st Report on Food Products and the 49th Report on Drug Products, 1956 By H J Fisher Pp 88 Bulletin 618 Report on Inspection and Analysis of Commercial Fertilizers, 1958 By H J Fisher Pp 72 Bulletin 619 Laboratory Studies on House Fly Populations By R L Beard Pp 12 Bulletin 620 Eastern Hemlock Seeds and Seedlings Response to Photoperiod and Temperature By Jerry S Olson, F W Stearns and Hans Bienstaedt Pp 70 Bulletin 621 The Alfalfa Weevil By R J Quinton Pp 16 Bulletin 622 Digested Sewage Sludge for Soil Improvement By Herbert A Lunt Pp 30 Bulletin 623 Nitrogen Sources for Connecticut Tobacco—a Report on the Co-operative Tests of 1958 By Henry C de Roo Pp 12 Circular 203 Control of Slugs, Sowbugs, Centipedes, and Millipedes in the Greenhouse and Garden By John C Schread Pp 8 Circular 204 The Orange-Striped Oakworm By John C Schread Pp 8 Circular 205 Eastern Hemlock Growth Cycle and Early Years By Jerry S Olson, F W Stearns and Hans Bienstaedt Pp 24 Circular 206 Pod Gall of Honey Locust By John C Schread Pp 4 Circular 207 The Red Pine Scale By Charles C Doane Pp 7 (New Haven, Conn Connecticut Agricultural Experiment Station, 1958 and 1959) [109

CERN (European Organization for Nuclear Research The CERN Proton Synchroton (1st Part) By E Regenstreif Pp xii+226 (CERN 59–29) (Geneva CERN, 1959) [249

South African Council for Scientific and Industrial Research National Nutrition Research Institute A Study of Principles of Food Enrichment and Their Application to Food Policy in South Africa—(With Special Reference to the Use of Fish Flour for the Protein Enrichment of Bread) Prepared by the National Nutrition Research Institute Pp vii+209 (Pretoria South African Council for Scientific and Industrial Research, 1959) [249

Conseil Permanent International pour l'Exploration de la Mer, Charlottenlund Slot, Danemark Bulletin Statistique des Pêches Maritimes Vol XLII pour l'Année 1957 Redigé par Arni Fridriksson Pp xiii+55 (Copenhague Andr Fred Høst & Fils, 1959) 9 00 kr [249

Memoire dell'Istituto Italiano di Idrobiologia Dott de Marchi, Vol XI Pp 272 (Milano Editore Ulrico Hoepli, 1959) [249

New Zealand Report of the Director of Forestry for the year ended 31 March 1959 Pp 169 (Wellington Government Printer, 1959) [249

Republic of the Sudan Ministry of Agriculture Forests Department Report for the period July 1957 to June 1958 Pp vii+94 (Khartoum Ministry of Agriculture, Forests Department, 1959) [249

Smithsonian Miscellaneous Collections Vol 138, No 5 A Biological Survey of Katmai National Monument By Victor H Cahalane Pp iii+246+17 plates (Publication 4376) (Washington, D C Smithsonian Institution, 1959) [249

New Zealand Report of the Department of Scientific and Industrial Research for the year ended 30 March 1959 Pp 112 (H 34) (Wellington Government Printer, 1959) [249

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